JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA.
FOR THE
PROMOTION OF THE MECHANIC ARTS.

VOL. LXIV.] OCTOBER, 1872. No. 4

# EDITORIAL.

## ITEMS AND NOVELTIES.

**A Rotary Shaper** *for Planing, Drilling and Boring Metal, &c.* —Built by C. Van Haagen & Co., Philadelphia.

This machine has been devised with the view of providing machine shops, and especially repairing shops, with a tool for a variety of purposes, which have heretofore required separate machines. It is universal and always ready for use, and can, without requiring any renewal or replacing of parts, be used for a variety of purposes; such as horizontal drilling or boring, turning, planing, key-seat cutting, gear-cutting and slotting; the latter operation can be so conducted as to cut either a vertical, horizontal, diagonal or angular slot.

On reference to the accompanying perspective drawing: A represents the cast-iron bed of the machine, F, a movable table attached to the front of the same, and C and B, a movable head stock and slide at the rear.

The table, F, which is intended to carry the object or objects to be operated upon, is arranged to move vertically, and the head stock, C, is furnished with a revolving spindle, D, and is arranged to be moved both longitudinally and transversely. All or any of these movements can be imparted to the table and head stock, by hand or automatically.

The vertical movement is imparted to the table, F, by a vertical screw spindle, not shown in the drawing, which derives its motion from a horizontal spindle, the end of which, provided with a crank, is seen projecting from the casing, I. By means of the crank the table can be raised or lowered by hand, while if it be desired to move it automatically, connection is made with the driving shaft, J, by an adjustment of the lever, which projects through the slot at the left-hand side of the casing, I.

The feed screw, H, by which the slide, B, is moved automatically upon the guides of the bed, derives its motion from the shaft, J, through the medium of cog gearing contained within the casing, I, and by adjusting a shifter, K, the direction of the motion of the transmitting gear can be changed in order to reverse the movements of both the slide, B, and table, F. Either or both of the latter can be thrown out of gear with the driving shaft, when it is necessary that they should remain at rest or be operated by hand. To operate the slide by hand, the half nut which engages with the feed screw, H, is drawn back from the latter by an adjustment of the screw spindle, L, after which it is only necessary to turn a pinion, which is hung to the side and adapted to the teeth of a rack, G, on the bed.

The required transverse movement can also be imparted to the head stock, C, either by hand or automatically. The hand movement being obtained by means of a rack and pinion, while if the head stock is to be operated automatically, a screw feed is employed, which derives its motion through the medium of a worm and wheel from the driving shaft, J.

When it is necessary to automatically reverse the movement of the parts, as in planing, for instance, adjustable lugs or stops are attached to the inner continuation of the driving shaft, J, which lugs are struck alternately by the slide, B, this having the effect of turning the shifter, K, and of consequently reversing the movement.

The power by which the machine is driven, both by the driving pulley, J, and spindle of the head stock, is derived from a single line shaft, S, which has its bearings in a hanger above the machine. As the driving pulley, J, of the machine has no travelling motion, it is driven directly by a belt extending downwards from a cone pulley on the shaft, S. In order, however, to accommodate the cone pulley, D, of the headstock in its various movements, a movable carriage, M, is employed, which runs freely upon the hangers, and carries a cone pulley, P, arranged to travel transversely across the carriage, so that

it will always follow and be directly above the pulley of the head stock.

The shaft, S, is squared and carries a conical grooved friction pulley, R, arranged to slide upon without turning independently of the shaft, and adapted to a corresponding pulley hung to the pulley shaft of the carriage. By means of this gear, which is self-adjusting to the movements of the carriage, a regular and uniform movement is imparted to the pulley, P, from the shaft, S.

In order to illustrate the operations of the machine, let it be supposed that a block of metal, suitably secured upon the table, F, is to be planed by a revolving tool, E, screwed into the spindle of the head stock, the table being properly set before commencing the work, and the parts so adjusted that the said table shall not be automatically raised or lowered. The stops or lugs are then properly adjusted upon the inner continuation of the driving shaft, and the machine set in motion. The head stock, carrying the tool, E, will first be carried in one direction until it strikes one of the above mentioned stops, which will have the effect of turning the shifter, K, and reversing the motion, and the head stock will then be moved in the opposite direction. The table is then raised or lowered as required, in order to present another portion of the surface of the block to the action of the tool, the latter moving backward and forward as the motion of the head stock is reversed, until the entire surface has been planed.

For horizontal drilling it will be only necessary to move the head stock, C, forward, either automatically or by hand, towards the object secured upon the table.

In slotting, a revolving tool is used, and the table, F, or the head stock, or both, will have to be moved either automatically or by hand, as the slot is vertical, horizontal, diagonal or angular.

For cutting the teeth of cog wheels a revolving tool is used also, and the wheel is secured in a horizontal position upon the table, to which a vertical reciprocating motion is imparted. The wheel thus placed upon the table should be secured to and be controlled by appropriate mechanism for determining the number of teeth and the proper distances between the same.

The machine can also be used for cutting key-seats in pulleys without removing the latter from the position in which they are secured upon the table, in order to be turned out inside. The cylinder of a steam-engine can likewise, when secured to the table, be bored out, faced off, and drilled for the bolts without being moved from its position.

Distance between spindle and table in lowest position, twenty-four inches; between spindle and top of bed frame, eighteen inches; and between spindle and top of slide rest, ten inches; driven by cone, with four changes for a three-inch belt, and double geared, giving eight speeds to spindle. Self and hand feeding with four changes. Head stock has twenty-seven inches traverse and rapid hand movement by crank, and moves longitudinally three feet nine inches, with eight changes of speed. Table moves vertically, two feet, with eight changes of speed, and swings and slides upon its bed.

The advantages claimed for this tool are that it combines in itself the functions of several machines, which have heretofore been separate.

That in dressing up a face it cuts continuously, as it moves forward, being capable of cutting or dressing a width of from one-half inch to ten inches in one cutting. The machine can be made to cut as smooth as glass, thus dispensing with the necessity of filing. Finally, its convertibility from one function to another makes it a most convenient adjunct to the machine-shop, since, by simply turning a hand-wheel to disengage a screw, it is converted from a planer into a boring machine, or, again, into a head lathe, by simply screwing to the head stock spindle a lathe face-plate, and fastening a tool-post or a slide-rest on the table opposite.

**Stevens' Institute of Technology.**—*Continued* from p. 147. Next to the room last mentioned is the Optical Cabinet, No. 14. In the centre of this room is a large glass case, about ten feet long, five feet wide and seven feet high, containing a number of large optical instruments, such as a telescope, a Biot's polariscope, a Dubsocq electric lantern, an Arago's differential-refractometer and Wheatstone's reflecting stereoscope, beside many other instruments. Around the walls are cases filled with instruments for every demonstration or measurement connected with the subject of optics. Thus the cases in the N. E. corner contain nothing but instruments bearing upon polarized light. Here are found the polariscopes of Arago, of Biot, of Noremberg, of Amici, of Airy, of Dove and of Wheatstone. The saccharometer of Soleil, and the cyanometer of Arago, together with countless special instruments or appliances by which important laws have been established by the classical investigators above named, or by which important measurements and determinations are to be reached in practical questions of to-day.

Here are to be found likewise a set of selenite objects colorless in themselves, but showing the brightest colors when their reflected images are viewed by reflected light in mirrors of black glass, which are the largest and finest ever produced.

These, with immense Nicol's prisms, Fresnell's prisms, and sections of every rare crystal, make an array of objects whose interest to the man of science is indescribable, and whose equal is certainly not to be found on this side of the Atlantic.

Another set of cases contain the apparatus used by Stokes and by Becquerel in their researches on Fluorescence and Phosphorescence, including duplicate sets of quartz prisms, lenses and tanks of the same material, beside numerous specimens of rare crystals cut and mounted for these experiments.

Other cases contain various forms of spectroscope, as well as every form of lens and prism, and their application, as well as the various instruments which have been devised to illustrate persistence of vision and other facts of subjective impression.

Before leaving this collection, we should say that it contains as an item the entire optical part of the Bancker Collection, and that among these is one with a curious history. This is the differential refractometer. It was originally ordered for the Egyptian Academy during the invasion of Egypt by Napoleon Bonaparte. Before the instrument could be finished, however, the battle of Trafalgar and other associated events rendered its delivery inexpedient. For some time it remained in the hands of its constructer, M. Soleil, until purchased by Mr. Bancker, at the suggestion of his friend and constant correspondent, the Abbè Moigno.

This instrument is also as interesting in its action as in its historic associations, but its description would require a separate paper.

Entering No. 15, we find it fitted up as a mixed work-shop, physical laboratory and study, being occupied by Prof. Mayer in all these capacities. At one side is a screw-cutting lathe; at another, a table especially fitted for optical researches; at yet another, a large study-table and cases for books and instruments, and everywhere generally instruments and books in philosophical order or confusion.

Passing next to room No. 16, we find here the lecture-room of the department of Physics, fitted like the other rooms with seats on successive platforms, and provided with every appliance by which experimental illustration can be facilitated. The lecture table contains a pneumatic tank and wash basin, and has laid on to it oxygen and hydro-

gen, as well as illuminating gas, vacuum, galvanic electricity and steam. Behind it a screen can be lowered at a moment's notice, and from the rear of the room projections thrown by means of the electric or oxy-hydrogen lights, which are "laid on," to that point also. The windows face the south-east, and are provided with screens, a portlumiere and heliostat, for the use of sun-light in illustrations before the class. Behind the lecture table are cases containing such apparatus as are most frequently in use, such as balances, air-pumps, glass vessels and the like, and passing to the left we enter a long narrow room, No. 17, lined with cases on either side, which are filled with all the various instruments needed to illustrate lectures on all the departments of Physics. Here are to be found the various models explanatory of the subject of elementary mechanics, of acoustics, including the entire Bancker collection in this department, supplemented by a large invoice of Kœnig's latest devices, of heat, of light and of electricity in its triple branches of Frictional, Galvanic and Magnetic.

An elevator at one end of this room makes easy communication for transfer of apparatus to and from the physical laboratory below.

Passing next to No. 18, which is President Morton's lecture room, we find it provided like the others with all appliances of gases, batteries, water, steam, screens, etc., and also exhibiting in its orderly confusion evidence of the various work of investigation and instruction which is going on within its walls.

The little room, No. 19, is the President's workshop, containing his lathe, and various tools, and having thus reached the end of this floor, we will reserve for our next issue an account of the third floor, with its rooms for Photometry, Photography, Electrical Measurement, Drawing, Blowpipe analysis, and the like.

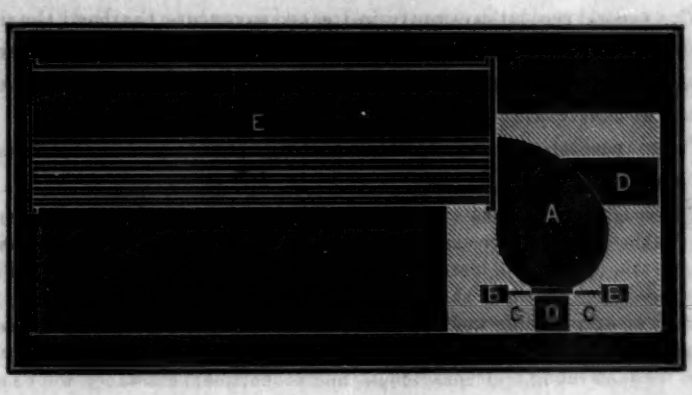
(To be continued.)

**The Horizontal Tubular Boiler.**—Patent, No. 3744, granted to M. M. Seguin & Co., of Lyons (France), for ten years, from the 22d Feb., 1828. The following is a nearly literal translation of the official description:

"*For an Improved Construction of a Boiler with Hollow Tubes.*—Steam being produced in proportion to the heating surface, it is believed that the simplest arrangement, occupying the least possible space, is that of a tubular boiler.

"This our invention consists, therefore, as will be seen from the drawing, in the employment of a greater or less number of tubes

through which the heat passes; and these tubes, surrounded by water, present a very extensive heating surface.




"The sketch shows the application of the invention to land boilers.

"A, the furnace, 'fed by a ventilator or otherwise.'

"B, air chambers.

"C, pipes introducing air into the fire-place.

"D, door for feeding fuel to the fire-place.

"E, 'tuyaux caloriferes,' or heating tubes.

"O, hearth."—*Colburn's "Locomotive Engineering,"* 1871.

J. H. C.

**Canal Navigation.**—The fact that the State of New York has offered a reward of $100,000 to the inventor of the most effectual plan of canal boat propulsion will be known to all of the readers of the "Journal." In the following we desire simply to call attention to a modification of the preliminary tests required, which was adopted at a meeting of the Commissioners on the 6th and 7th of August last. The modification to which reference is made consists in the amendment of the following resolutions, adopted at the earlier meetings of the Commission, viz.:

"*Resolved*, That, for the purpose of carrying out the intent of the law, this Commission will require, among the tests to be made, that the several competitors shall make not less than three round trips, from New York to Buffalo or Oswego; each boat to be loaded with not less than 200 tons of cargo each way; the trip to be commenced as soon as any party is ready, and all completed in the least practicable time. For the purpose of determining the time consumed by each and all the trips, the clearance must show the day of the month and the time of day that the boat passes each collector's office; certified copies thereof to be furnished to the Commission. In order to obtain information in regard to the practical working of the several devices in competition, as soon

as practicable, the Engineer of the Commission, Mr. David M. Greene, of Troy, will inspect the same from time to time, as in his judgment may be necessary, and report the facts obtained to this Commission."

The second resolution simply indicated inventors that had the whole of the year 1872 at their disposal, in which to make their experimental trips, and that the awards would not be made until the close of navigation in that year.

These resolutions were, at the meeting above named, modified by the passage of the following:

"*Resolved*, That the boats making the three round trips from Buffalo or Oswego to the Hudson River and return, as heretofore required by this Commission, for the purpose of determining the rate of speed of said boats, will not be required to continue the trips to New York City, nor to carry more than 100 tons of cargo going west, and that deduction from the time consumed in navigating the canals will be made in passing the locks, equal to twenty-four hours for each round trip from Buffalo, and proportional allowance will be made if the trial is from Oswego. In case of delays growing out of obstructions to navigation that are caused by breaks in the canals, or injuries to the structures, or sunken boats, or such as detain boats drawn by horses, the time lost will also be allowed for in computing speed."

The next meeting of the Commission will be held Tuesday, October 1st, at 3 P.M., at the office of the Canal Commissioners, in the City of Syracuse.

**Coal-Cutting Machinery.**—At the recent meeting of the English Mechanical Engineers, at Liverpool, a visit was made by a section of the party to the Platt-lane Colliery, to witness the operation of the coal-cutting machinery of Mr. Winstanley, a notice of which appeared in the preceding number of the "Journal."

From a more detailed description of its construction and operation which appears in a contemporary,* we condense the following information:

One of the machines has been at work for two years in a seam of coal 2 ft. 4 in. in thickness, which is notoriously hard, so much so that at one time it stood unworked, from the unwillingness of the miners to work it. The cutter is driven by compressed air, which is conveyed down the shaft and along the main roads to iron pipes, and to the machine in India rubber hose pipes, 2 in. in diameter. The coal is cut by a spur-wheel, fitted with teeth, this wheel being 3 ft. 6 in. in diameter. No previous "holing" is required in its operation. The machine is drawn along the face of the coal as it cuts its way, throw-

* The Engineer, xxxiv, 99.

ing out the slack between the tram rails upon which the machine runs.

The chief advantages claimed for it are: 1st. The "swivel movement," by which means the cutter holes its own way into the coal, cutting from nothing up to 3 ft.; and for bringing the cutter back underneath the framework of the machine when not at work, thus allowing its transportation through narrow ways without removing the wheel. 2d. Applying the power to drive the cutting wheel directly on the periphery of the wheel, and the allowing of the waste to fall through to the bottom without clogging the teeth of the machine.

The average rate of "holing" by the machine is from 25 to 30 yards per hour, according to the quality of the material, and it had frequently cut the whole length of the face of 120 yards in a night. As in this mine 5 yards per day is considered above the average of the work of a miner with the pick, the work of the machine may be estimated as equal to that of 40 men. The machine works at night, the coal being removed by day by manual labor. It is, moreover, asserted that this particular seam could not be worked save by the machine; or, if men could be obtained for it, the proportion of coal to slack would be 3 to 1, while with the machine it is 8 to 1.

The actual cost of getting out the coal by machine and by hand labor has been found, by the payments made during a period of six weeks at the Platt-lane Colliery, to be as follows: Hand labor, 3s. 6½d. per ton; machine labor, 3s. 1½d.; showing a saving of 5d. per ton by the latter.

The statistical account above given would not be complete without the statement that the machine in question, at the time of the visit of the Society, had been in operation for six months with little or no repair.

Finally, in view of the fact that the expediency of introducing coal-cutting machinery is a question of annually increasing importance, the above details acquire considerable weight, since they are the first reliable and well-digested facts collected upon the subject, and extending over a considerable space of time.

**Harlem River Tunnel.**—We are indebted to our excellent contemporary, the "Chicago Railroad Review," for the facts concerning this engineering enterprise contained below:

To bring the northern and western portion of the island covered by New York City into a closer communication with Westchester County has been a

consummation long and loudly called for by the exigencies of an immense and growing internal commerce between those sections. As one means of effecting easy intercommunication, a tunnel under the Harlem has been under consideration ever since December, 1869. In 1871 the Legislature empowered officials on behalf of the city and Westchester County to acquire the necessary land titles and construct such a tunnel as might be planned, etc. Immediate surveys were made and elaborate plans drawn up, but the discovery of the "ring" frauds retarded their execution. The work, however, has been renewed, and the officials are considering plans for a tunnel of solid masonry, to extend 1663 feet on the New York and 1078 on the Westchester side of the river. The top of the arch to be 18 ft. below high-water mark, so that vessels drawing 17 ft. can pass over safely. The tide falls about 5 ft. at that point, and at low tide vessels drawing less than 13 feet will be able to pass over in safety. The tunnel to be about 2759 ft. long, 16 ft. high (so as to permit persons to stand on top of the highest omnibus) and 34 feet wide, affording 20 ft. of wheeling space and 7 ft. on each side for foot passengers. The descent will begin at 150th st., and the top of the tunnel will strike the water-bed at 155th st., about 200 ft. south of the present Macomb's Dam bridge. The descent will not be steeper than many of the roads in the Central Park, and will not inconvenience horses drawing heavy loads. The expense is estimated at about $1,500,000. The reasons for such a structure at that point are deemed by the New York press as many and cogent, an especial one being the saving of all interruption to navigation. Careful examinations disclose, it is stated, the perfect feasibility of such a work.

Another plan is also progressing, which in magnitude is, perhaps, even greater than that for a tunnel. It is that of a suspension bridge.

An act of 1871 gave Commissioners authority to begin a suspension bridge not more than half a mile north of the High Bridge, and shortly afterward surveys were made and plans drawn up. But the same causes which delayed work on the tunnel stopped progress in this enterprise, until recently, when the Commissioners resolved to construct the suspension bridge at the point named. This will be about 1800 ft. in length—734 ft. in the jurisdiction of New York, and 1066½ ft. in Westchester County. The roadway will be about 153 ft above high-water level, and extend from the 10th avenue to the heights on the opposite shore, west of the Croton Aqueduct. It will be 23 ft. higher than the present High Bridge, and form a convenient connection between the elevated lands of both sides of the river, affording favorable ground for foundations for piers, towers, and anchorage for cables. The only difference in cost between it and a bridge over and resting on the Croton Aqueduct bridge is the cost of towers and anchorage. Estimates of the cost of the work do not appear.

**Influence of Coal Gas upon Vegetation.**—Dr. Virchow* announces, as the result of a thorough examination of the subject by a scientific commission ordered by the municipal government of Berlin, and of which he was a member, that the infiltration of coal gas in the soil whereon trees, shrubs and ornamental plants are grown, is decid-

* Journal für Gasbeleuchtung, No. 8, 1872.

The following statement of the areas of the several coal-fields is of importance, viz.:

| | | | | |
|---|---|---|---|---|
| Schuylkill Coal-field (Southern), | Sq. miles, | 146 | Acres, | 93,440 |
| Second or Middle Coal-field, | " | 126 | " | 80,640 |
| Third or Northern Coal-field, | " | 198 | " | 126,720 |
| Total Area of the Anthracite Coal fields, | " | 470 | " | 300,800 |

The total production of anthracite from 1820 to 1870 (fifty years) is estimated at 206,668,325 tons; while, as a comparison and an indication of what may reasonably be expected in the not distant future, from the growth of our industries, the production of Great Britain for one year (1870), is placed beside it at the colossal figure of 110,431,192 tons.

Perhaps the most interesting portion of Mr. Sheafer's report, though it is purely speculative in character, is that in which he estimates the contents of the various fields and the probable amount of coal still remaining to be mined, viz.:

| | | |
|---|---|---|
| Taking the average thickness of the Southern field at 75 feet, and that of the Middle and Northern fields at 45 feet, he estimates the total contents of the anthracite region, | Tons, | 26,361,076,000 |
| Or the practical contents (deducting 50 per cent. for waste), | " | 13,180,508,000 |
| Already mined out 206,666,325 tons, doubled for waste, | " | 412,332,750 |
| Balance to be mined, | " | 12,768,175,250 |

Taking Mr. Sheafer's estimate of the probable supply still on hand to approximate tolerably to the truth, our anthracite fields would, at our present rate of production, be entirely exhausted in about 850 years, while at the rate of production attained by Great Britain the period would be shortened to about 110 years.

**International Patent System.**—The following notice, bearing upon the urgent need of reform in the system of granting patents extant in various countries, has lately been received, through the kindness of Dr. Haseltine, of London, England:

The recent deputation, which included Mr. Macfie, M.P., Mr. Webster, Q.C., Mr. Johnston, M.P., Dr. Haseltine, and Mr. Wise, C.E., have, by invitation, presented to his Lordship and the Duke of Argyle a written statement of their views on this subject. It is suggested that negotiations should at once be initiated in accordance with the last resolution of the Select Committee of the House of Commons, who recommend "an assimilation in the law and practice with respect to inventions among the various civilized countries of the world,

and that Her Majesty's Government be requested to inquire of foreign and colonial Governments whether they are ready to concur in International arrangements in relation thereto." Three modes of procedure are presented for consideration: (1) An International conference; (2) Correspondence between the ministries of the various States and Colonies; (3) Communications between heads of the different patent offices. Some of the desired objects, it is thought, may be obtained by an assimilation of the official rules, as the patent laws in many States are similar in principle, though legislation may be requisite to secure a substantial uniformity in the practice under the various systems. The deputation are of opinion that the grant of Letters Patent should be confined, as recommended in the ninth resolution of the Select Committee, to "original inventors, their assignees, or authorized agents," and they regard the recognition of the rights of the authors of inventions as indispensable to an International system. They state that an organized practice of "pirating" inventions exists, whereby foreign inventors are often deprived of their rights by "*first importers*," who anticipate them in their applications for English Patents. The deputation submit these suggestions, which accord, they state, with the recommendations of the Select Committee, and they respectfully ask that early action may be taken by the Government calculated to secure uniformity in the various systems of granting patents for new inventions.

## THE ILLINOIS AND ST. LOUIS BRIDGE.

We are permitted to lay before the readers of the Journal the following statement of the present state of the work upon this structure, for the facts of which we are indebted to the courtesy of Col. James B. Eads, the Chief Engineer of the bridge.

The entire masonry of the bridge will be completed during the month of October next. The west abutment, the west pier, and the extensive line of masonry constituting the west approach, extending to Third street in St. Louis, are all completed. The east channel pier is built up to the top of the upper skewbacks of the arches. The east abutment pier is up to the level of the railway tracks, and the east approach across the wharf is nearly completed. Of the entire 102,000 cubic yards of masonry contained in the completed structure, only six thousand remain to be laid.

The superstructure is being rapidly pushed forward in the Keystone Bridge Works at Pittsburgh, and several shipments of it have been received at St. Louis. Three of the skewbacks, with their steel tubes attached, are already put up in their respective places on the west abutment. These constitute the first members of the great steel arch that will span the opening (500 feet wide) between the west abutment and the west channel pier. This arch will require about 340 steel tubes, such as those now in position in these three skewbacks.

These tubes are all finished at Pittsburgh, and are being fitted to the couplings that will connect them together. As fast as this is done they will be shipped forward. Sixteen skewbacks are required for each arch. Those needed for this arch are finished, and most of them are at St. Louis or on the way; all but four required for the other two arches are finished. These skewbacks are of a very inconvenient form for forging; but more beautiful and perfect forgings in wrought iron are not to be found anywhere. They weigh about six tons apiece, and each one is calculated to resist a strain of six thousand tons.

The steel tubes are being finished at the rate of 40 per week, and the lathes are driven night and day in finishing them. The first one required about 60 hours in the lathe. The improvements made, however, in working the steel at the shops have been so great, that they are now completed in from 12 to 14 hours. Ten hundred and thirty-six of these tubes will be in the three arches.

The steel is being delivered with great regularity from the William Butcher Steel Works. The uniformity in strength and quality is remarkable, and the staves for the tubes are turned out with the ease of bar iron.

The statements made by some of the scientific papers that wrought iron anchor bolts had to be substituted instead of the steel ones originally designed, because the steel ones were found incapable of standing the tests, is untrue. We have the authority of the Chief Engineer of the Bridge for this statement. Many of the first steel bolts made did fail to stand the test, but all of those made during the last eight or nine months, without exception, stood the highest strain which the testing-machine could exert, which was 520 tons. This was more than double that which was applied to the wrought iron ones of equal section. About 170 of these bolts were made, part of which were originally designed of iron. The delay in getting the steel bolts at first induced the ordering of a large number of iron ones to save time. More than 100 of the whole number are, however, of steel, and each of these has been subjected to a strain of 40,000 lbs. per sq. inch (all that could be put on it), while the iron ones were subjected to but 18,000 pounds per square inch. The samples of steel cut from the bolts stood strains ranging from 95,000 to 140,000 pounds before fracture. These bolts are from 22 to 36 feet long, and 5¾ inch diameter. The President of the Steel Works, Mr. Samuel Huston, declares that there is no chrome in any of those metals within the

last eight or nine months, and which have proved so satisfactory. In this connection, it may be well to explain that the *safety* of the arches is in no wise dependent upon these bolts. If all of them were broken off at the same instant the arches would be undisturbed and just as safe. Their purpose is, however, a double one. By bolting the skewbacks firmly to the masonry they prevent their movement, and thus promote the *durability* of the structure. A slight movement of the skewbacks would otherwise be inevitable during the extremes of temperature. When these movements occur the entire weight of the arches will rest either against the upper or the lower skewbacks, according as it is hot or cold. Those which are relieved of pressure would, in great extremes, even be drawn a fraction of an inch from the masonry but for these bolts. The other purpose which they serve is to give increased stiffness to the arches under the strains of unequal loading; producing an effect similar to that given to a beam inserted rigidly into a wall, instead of allowing the same beam to simply rest on it. Without them, greater deflection on the one haunch or the other of the arch would occur if all the load were on one-half of the span, and the other remained unloaded. This deflection would create additional strains and movements in the various joints of the bridge, and thus lessen its durability.

It is believed that the first span will be completed next December, and that the railways of the bridge can be opened by the last of March or in April next. The upper roadway will be completed probably six or eight weeks later.

The tunnel connecting the Western railways with the bridge will be put under contract on the 14th inst., and will be finished by the time the bridge is opened.

A large portion of the upper roadway between Third street and the wharf, in St. Louis, is laid, and already shows its capacious proportions. It is simply an extension of one of the finest and most central avenues in St. Louis across the river into Illinois. The street and alley bridges in this approach are all up, and the stringers are ready for the steam railways from Third street to the face of the west abutment below, and for the street railways on the roadway above—a distance of over 1000 feet.

# Civil and Mechanical Engineering.

## TRANSMISSION OF MOTION.

*A Lecture delivered by* COLEMAN SELLERS *at the Stevens' Institute of Technology, Hoboken, N. J., February 19th, 1872.*

Revised for publication in the "Journal of the Franklin Institute."

The particular branch of the subject of the transmission of motion to which I shall call your attention this evening, is what is technically called *shafting* and *mill gearing*, and relates to the transmission of motion from the motor to the machine. The motor, or source of motion, whether it be a wind-mill, a water-wheel, a steam-engine, or a lady's foot upon the treadle of a sewing-machine, must be connected with the machine that does the work. This connection may be of the simplest and most direct kind imaginable, or it may be very complex. It often involves the use of long lines of shafting, may be much gearing, and various ingenious arrangements of belts and pulleys. In any large factory the shafting, with its couplings, pulleys and other adjuncts, considered as a machine to transmit motion, is most frequently the largest in the establishment, hence every consideration of economy requires that it should do its allotted work with the least possible loss of power in the transmission. It calls for economy in first cost, and economy in use.

The generation of power to be expended in operating machines to do work costs something; it may cost much money in fuel consumed, or it may cost something in energy expended. In any case, the more perfectly the whole power is transmitted to the work, the more profitable will be its use.

It is a noteworthy historical fact, that economy in the generation of power in the motor, and economy in the utilization of the power in the machine, have been in most countries far in advance of the economical transmission of power from one to the other. Years ago there were excellent models of water-wheels, and by them were driven machines of surprising ingenuity, but the power was conveyed by means of cumbersome wooden shafts upon which were wooden drums for the driving belts; gearing too, made of wood, slow-moving, awkward contrivances for the purpose, and very wasteful of power.

One does not need to be a very old man to recollect the introduc-

tion of machinery for making clothing for cards, for forming and sticking into sheets of leather the delicate wire teeth used in carding cotton and wool. The card-making machines perforated the leather, bent the delicate wire into proper shape, inserted them into the perforations, then adjusted the final shape and left them of sufficiently uniform length. These were and are now, machines of wonderful ingenuity; yet these machines were driven from wooden drums, on wooden shafts, held up in wooden bearings. These very same machines, used more than forty years ago, and so driven, are many of them running to-day, answering all the requirements for which they were made; but they are now driven from metal shafts, running in metal hangers, coupled in an ingenious manner, and driven from iron pulleys, smooth-turned on their faces and carefully balanced.

The high-pressure engine of Oliver Evans was not a great deal behind the steam-engines of the present day, and he, as a leading millwright, wrote a book on this very subject of transmission of power. He called it his Millwrights' Guide, and, in describing the practice that obtained in his day, he tells of wooden shafts, wooden drums and wooden gearing only.

In the progress of the art, it is quite evident that early engineers in iron took their ideas from what had been done in wood. They copied in iron what had been the practice in wood. Cumbersome, slow-moving iron shafts took the place of slow-moving wooden shafts. Gear-wheels were used to transmit the power from the motor to the shafts, and from shaft to shaft in the various rooms and situations requiring power; while belts or bands from pulleys were only used to transmit the power from the shafts to the individual machines. The practice of high-speeded shafts, and the entire substitution of belting for gear-wheels, that I shall describe to you this evening, belongs essentially to this country. The value of high speed in belts has been long known in England and in some parts of Europe, and many wonderful examples there exist of its application. These examples are, however, exceptional, and have not come to be general mill practice.

When I explain to you the method of transmission in common use in this country, you will see that it bears the stamp of originality, and differs essentially from the more costly and cumbersome practice of the mother-country.

It gives me pleasure to note this essential difference, for the first time in public, in the Stevens Institute of Technology, an institution

founded by an enthusiastic engineer, and devoted to the teaching of what is the most useful to the practical engineer of this day.

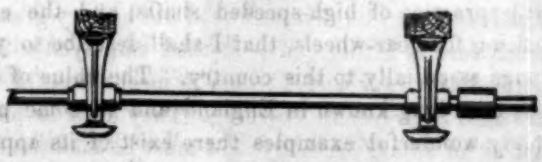
It may be well to note that in a book published in London in 1841 —Principles of Mechanism, by Robert Willis, M.A., F.R.S.—mention is made of the use of belts, and what was the practice in America at that time, in these words:

"Belts, on account of their silent and quiet action, are very much employed for machinery in London, to avoid nuisance to neighbors. It appears, also, from a recent work,* that the use of belts is greatly extended in American factories. In Great Britain the motion is conveyed from the first moving power to the different buildings and apartments of a factory by means of long shafts and toothed wheels, but in America by large belts, moving rapidly, of the breadth of 12 or 15 inches, according to the force they have to exert."

What Prof. Willis says in regard to American practice has continued to be the practice since this was written, but has been vastly extended; wider belts and faster running shafts have come into general use, while this extensive use of belting has been used in very few cases abroad, even up to the present time.

I have already mentioned line-shafting as a *machine* for transmitting motion. I wish you to keep it in mind as a machine, as perfect a machine in its way as is a steam engine that drives the shafting, or as a loom driven by it. It is a machine of many parts and various functions. Its purpose is to convey the power entrusted to it with as little loss by the way as is possible. This machine, in one of its simplest forms, is shown in a single shaft revolving in bearings, such as I here show you; or a number of such shafts, coupled to form a longer line; that is, a number of round bars of iron, united by couplings so as to form a continuous cylinder of the required length.

Fig. 1.



It must be supported in bearings at intervals, so arranged as to allow the cylinder to rotate freely about its longitudinal axis, while they sustain that axis in a right line.

In the first place, the independent bars forming the line must be

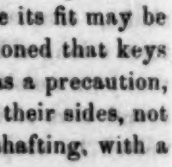
* Cotton Manufacture of America, by J. Montgomery, 1840, p. 19.

made truly cylindrical, and then be securely united one to the other. The uniting device is called the coupling. Since the introduction of turned iron shafts a great many contrivances have been used to unite shafts.

It must be borne in mind that the coupling should be of such a nature, that the strength and rigidity at the joint shall be as great if not greater than in any part of the line, so that if the line be subjected to flexure, it will bend anywhere else than in the coupling. In England, up to the present time, it is considered good practice to make the ends of all shafts larger than the body of the shaft by forging, and then to these enlarged parts secure the couplings by various and sometimes expensive means. Shafts so enlarged at the ends cannot be made to receive carefully bored pulleys unless the pulleys be made in halves, bolted together upon the shaft. Shafts come from the rolling mill, of certain merchantable sizes, as round iron. These round bars, when turned so as to be of uniform diameter, should be united without the extra cost of enlarging the ends. The first really good coupling used for this purpose was what is known as the plate coupling. This coupling, fig. 2, consists of two plates, with stout hubs, fitted with great care to the ends of the shafts to be coupled, and the plates then held together by very carefully fitted bolts, *a a*, which are turned and fitted into reamed holes. There are also keys (*b*) provided to prevent the couplings turning on the shafts. This, when well made, is an excellent form of coupling, but it has manifest disadvantages; its first cost need not be very great, but it requires too much care in fitting. The method employed to insure its fit may be noticed as a very useful lesson in mechanics. I mentioned that keys are used to prevent its turning. They must be put in as a precaution, not as an actual necessity, and must be made to fit on their sides, not on their top or bottom. See fig. 3. One section of shafting, with a half-coupling on each end, would look a good deal like a car-axle with a car-wheel on each end; and the same rule that applies to putting car-wheels upon their axles holds good for the placing of plate couplings. Car-wheels are bored to some standard size, truly cylindrical in their eye. The axles are then turned to a size somewhat larger than the hole

Fig. 2.

Fig. 3.



in the wheel; say, for instance, a four-inch axle is made ·015 of an inch larger than the hole into which it is to be fitted. Then the wheel is forced on to the axle by means of a powerful screw or hydraulic press. The force required is about thirty or thirty-five tons. Wheels so put on have no key to keep them from turning, and do not work loose. Plate couplings must be fitted in precisely the same manner. If a plate coupling be so fitted as to slide on and off easily, and an attempt be made to hold it in place by a taper key, fitting top and bottom, the pressure on the shaft will be on two opposite lines only, and sooner or later such coupling will work loose. To drive in a taper key is the very surest way to break or burst the surrounding metal, or at least make it run out of true. I cannot too strongly condemn the use of taper keys in all similar cases. A plate coupling, when properly fitted, requires great force to remove it, when its removal is needed for the placement of pulleys on the line, and frequent removal injures its fit. It also necessitates the use of open sided or hook hangers, as the coupling cannot be put on after the shaft is in place. These hangers, for equal strength, require double the metal used in a hanger with metal on both sides of the box. See Fig. 4. The greatest objection, however, to the use of this and similar kinds of coupling is in the fact that skilled labor is required to insure accurate fits, and that no practicable system of inspection will enable the mill owner to know that the fits are good ones. The working out of any shaft from its coupling may result in the fall of the section of shaft, the breaking of valuable machinery, or, too often, the loss of life. I have the pleasure of presenting to your notice, this evening, a coupling which, while it fills all the requirements of absolute security, can be cheaply made, and admits of ready removal and

Fig. 4.

ready adjustment when pulleys, &c., are to be added or changed. This coupling, Fig. 5, called by its manufacturers the double cone vice coupling, you will observe, consists of three principal parts—an outer sleeve, *a*, and two inner sleeves, *b b*. The outer sleeve has its interior surface made like two frustums of cones, with the apex of each meeting in the centre of the sleeve. *b b* are conical sleeves, bored to fit on the shafts intended to be coupled, and having their outer surfaces so turned as to fit into the conical holes of the outer sleeve, *a*. The cones *b b*, you will observe, have three equidistant square slots cut in them, and there are corresponding slots on the inside of the outer sleeve. These slots are to receive square bolts, *c c c*. The sleeves, *b b*, when put into place in the outer sleeve, will not quite meet, *i. e.*, they are too large to go in all the way. They are, however, split, each one, in one of the square slots at *d*. This split makes them elastic, and if they be forced into the conical holes they will contract, and thus diminish the size of the centre holes. The square bolts, *c c c*, while they serve as keys to prevent the inner sleeves from turning, also serve as a means of drawing the conical sleeves towards one another; so that if the ends of shafts be in these sleeves, such ends will be pinched or held fast by the pressure, and that in proportion to the force used in screwing up the bolts. Now I wish you to notice particularly this important feature. One cone cannot be drawn in with any more force than the other one; the resistance is the pressure on the shaft ends. The pressure on both ends of shafts in such a coupling must be equal, and is under the control of the person using and applying the coupling. The shafts need not be of exactly the same size; shafts of an appreciable difference in size may be as firmly held as if they were of the same diameter. Key slots are provided as a

Fig. 5.

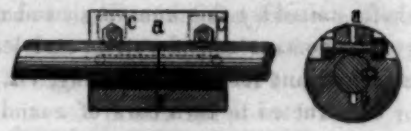
precautionary matter, as shown at *e e*: but the keys must, as I have before stated, fit sideways, and not touch top or bottom. That the shafts united by this coupling need not be of the same diameter is a very important consideration, and leads us to dwell for a moment on an important feature of shafting, viz., its *cost*. Machines can readily be constructed to turn bars of round iron in the condition they come from the rolling mill to a nearly uniform size, with great rapidity and at a very small cost. The expression, *nearly uniform*, I use advisedly. I mean that shafts can be turned so that a standard hardened gauge can slide over them and seemingly they will be of uniform diameter, but a careful measurement would show them to be only approximately alike in size. They are what may be called commercially accurate. This commercial accuracy represents a certain cost of production. Absolute accuracy, were such a thing possible, would represent a cost many times greater. Commercial accuracy is attainable by machines and by unskilled labor; absolute accuracy would involve more costly processes and the utmost skill of the most experienced workmen. When the plate coupling was in common use the bodies of the shafts were made of one size, and the coupling ends reduced by skilled workmen to a smaller size and carefully fitted to the coupling. It was this fitting that was costly. With the cone coupling this fitting is dispensed with, and shafts are sold as they come from the turning machines. An adjustable coupling, to be good for anything, must clamp each end uniformly. To impress this more forcibly on your minds, I will give you some negative information.

There are, and have been for years, many forms of adjustable couplings in use which do not fill this requirement. Let us take as an example one shown in Fig. 6, in which one long conical sleeve, *a*, fits in a conical hole in the outer sleeve, *b*, and the shafts to be coupled meet in the centre, at *c*. The cone (*a*) being split as are the cones in the coupling before described, the conical sleeve, when forced in, will be compressed upon the two ends of the shafts, provided these ends are of exactly the same diameter; but if one is ever so little larger than the other end it will be held, and the smaller end will be loose, and, what is more, no amount of pressure exerted by the bolts will make such a coupling hold the smaller one as firmly as the larger end. So, again, a coupling made as shown in Fig. 7, which represents a plain cylin-

Fig. 6.

drical sleeve, split through at *a* and partly through at *b*, so as to render it elastic, and is compressed by bolts *c*—such a coupling will hold shafts of exactly the same size, but will produce an unequal pressure on shafts of slightly different diameters. In practice, this latter coupling is made to hold by means of a peculiar key, which extends over the two ends of the shafts to be united, and is provided with pins at its end, fitted into holes drilled in each shaft. While on the subject of adjustable couplings, it may be well to remark that in putting them on the shafts they should be put on with a view to removal. All parts should be well and carefully oiled, so as to avoid all chances of their rusting fast. And in event of required removal it is best to slack up the bolts, and if not then loose, a few blows upon the outer shell with a billet of wood may start it loose. In case of the double cone coupling, a wedge, say a cold chisel, driven into the split in inner cone always loosens the cones and frees the coupling.

Fig. 7.

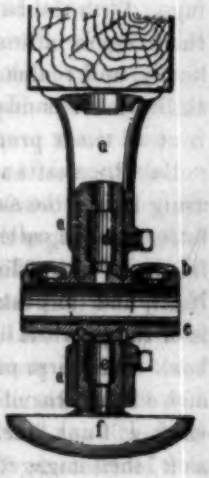



When the double cone coupling was first made, it was subjected to severe trials to test its utility. The experiment was made by coupling two shafts, which were placed on three bearings 10 feet apart, the coupling being near to the middle one. The hangers were so placed as to bend the shaft 1¾ inches out of line. These shafts so coupled were then made to revolve 250 revolutions per minute for many weeks during working hours, and yet the coupling did not loosen under this severe strain. Since that time they have been made by thousands, and are in use in all parts of our country.

Next to the proper means of uniting the shafts, come the devices to sustain the shafts and permit them to revolve freely on their axes. When shafting is to be suspended under the ceiling of a room, it is provided with what are called hangers. When it passes over the top of beams or near to the floor, it is carried on what are called pillow blocks. When near to posts the hangers are changed in form, and are called post hangers. All the devices have certain parts in common. They have, in the first place, a journal box or bearing, to receive the shaft; then some form of frame to carry the "box." A good many years ago,—I think, perhaps, thirty years at least,—a Mr. Edward Bancroft, then engaged in the machine business in Providence, R. I., invented what was called the swivel hanger. He saw that it was of

the utmost importance that the bearing provided should receive the weight of the shaft over its entire length. He also saw that a long bearing would last longer than a short one, if the pressure was uniform over its whole surface. So he made the box in such a manner that it should be carried by a kind of universal joint; he hung it on pivots, and made the axis of vibration coincide with the centre of the box. This swivel hanger was afterwards superseded by what is called the ball and socket hanger, now in almost universal use in this country, and which I will presently explain to you. Before the introduction of the swivel hanger, rigid bearings were the only kind used—I mean bearings which could not adjust themselves to the positions of the shafts—and such rigid bearings are still used in Europe. I have found an example of a rigid bearing in Prof. Thurston's room, among models received from Europe as examples of devices in common use. I may have occasion to refer to this later. When Mr. Bancroft had demonstrated the great advantages of the swivel or self-adjusting hanger bearing, he showed it to most of the prominent machine builders in the New England States, and tried to introduce it generally; but not one could be found who was willing to undertake its manufacture. They characterized it as a needless piece of refinement, and far too costly to be generally used. Mr. Bancroft afterwards, in connection with Mr. William Sellers, under the firm name of Bancroft & Sellers, manufactured this hanger, and introduced it extensively. In its modified form, but the same in principle, it is now come into universal use. Time will not permit me to show you the various forms through which this hanger passed. What is known as the ball and socket hanger, is what it has grown into. Various circumstances have, from time to time, caused modification in the form of the supporting frame, but the principle has remained unchanged. Fig. 8 shows a section of the modern hanger. The part marked a is the frame or hanger; b, the top box, and c, the bottom box, the two halves united, forming what is called the "box," *i. e.*, the journal box or bearing—the bearing in which the shaft rotates. This box is provided, top and bottom, with spherical surfaces, so placed as to be, in reality, portions of a sphere which has its centre in the centre of the axis of the box; d and e are what are called

Fig. 8.



the plungers. These are screwed into the frame, and are provided with cup-shaped ends to clasp the spherical parts of the box. The box can rock to a limited extent in every direction in these cup-shaped ends. The plungers serve a double purpose; 1st, of providing the socket for the sphere to roll in; 2d, to permit of a vertical adjustment of the entire box to bring them in line one with another; f is an oil dish to catch the drippings from the box. It is quite evident that a shaft placed in such a bearing will control the positions of the box, and will press uniformly over the entire length of the box. This is a very important feature, and I solicit your earnest attention to its advantages as compared to a rigid bearing. Imagine, if you please, a hanger in all respects like the one I have shown you, but with its box made in one piece with its frame. These hangers are to be attached to beams, some distance from each other, and they must be bolted securely to the beams in such positions as will insure all the boxes in the entire series being in line one with another, so that a shaft placed in the boxes will rotate freely without binding. You can readily see that to do this the foot of the hanger must be carefully fitted to the beam, so that a line stretched through the various boxes will touch all parts of each. This involves great skill and much time in putting up. This skill and time is at the cost of the purchaser and user of the hanger. Then when they are in place, the warping or twisting or sinking down of any one beam will throw the bearing out of line, and thus tend to cramp the shaft on its bearings. With the ball and socket hanger, care is only required to bring the hangers in line side-ways; the plungers admit of adjustment vertically, and the shafts twist the box into line with itself. Thus all skilled labor is dispensed with in putting up, and possible adjustment is at all times practical.

But the most important feature of this hanger is the possibility of using longer bearings or boxes than with the rigid hanger. With the latter, the longer the box the more difficult to line, and the more useless friction if out of line. With the swivelling principle, the box adjusts itself, and thus takes a uniform bearing over its entire length. This is of the greatest importance, and influences the material forming the box. With a pressure not exceeding fifty pounds per square inch, and oil well distributed over the surface of the box, the metal of the shaft will not touch the surface of the box, it will run on the oil used as a lubricator. The oil under this pressure is not squeezed out, and maintains its lubricating properties for a long time. Hence, if

the shaft does not touch the box, it matters little what metal is used in making the box. Cast-iron is the cheapest and most readily worked into shape. It is, in reality, the most durable of the metals for the purpose if kept well oiled, but the poorest if allowed to run dry. Brass or bronze has been used to a great extent, and lately a metal called Babbitt's metal has met with favor as a lining metal for boxes, but I may mention that a cast-iron nut on a lead screw of a lathe will outwear a brass nut two to one, and cast-iron gear wheels are much more durable than brass under limited pressure. I mean if the pressure on two pairs of wheels, one pair iron and one pair brass, be the same, and the pressure on both be within the limit at which cast-iron will run without breaking, the cast-iron wheels will last much the longest. Brass is resorted to for greater toughness, not for durability. The soft metals, under the general term of Babbitt's metal, are cast into recesses in journal bearings, and are extensively used. There are places where its use is advantageous, but for shafting purposes its use is to be discouraged. All soft metals, while they do not cut when permitted to run dry, in the way cast-iron is sure to do, yet they serve to catch the grit and dirt in the atmosphere which finds its way in with the oil, and the soft metal holds these little sharp particles, and thus gradually grinds down the shaft running in it. When it is desired to grind down a cylinder of hard metal, lead clamps are applied to its surface very like journal boxes, and into these clamps oil and emery is fed. The lead will hold the emery, and thus reduce the size of the hard metal without serious wear on its own part. Many of you may have heard that the use of soft metal is cheap. You will have been told that boxes cast with a recess to hold the soft metal can be used as they come from the foundry, and thus all labor of boring and fitting be dispensed with; the shaft can be laid in place on the cast-iron shell, and soft metal, melted in a ladle, can be poured in, thus filling the recess and insuring a fit. This sounds very plausible. Let us analyze it, as is proper in all such cases. The box with its recess must be rather larger, to be of equal strength, with one cast without such recess. Babbitt's metal costs much more than cast-iron; we may safely say it costs ten times as much. The melting and pouring and fussing over the job takes time, which cost money. Now, in point of fact, a pair of cast-iron boxes can be planed on their faces, then bored to fit the shaft, and grooved for oil passages, for less than half of what the least quantity of soft metal would cost that can be used in such a box.

(To be continued.)

## HINTS ON MECHANICAL DRAUGHTING FOR APPRENTICES.

By J. Richards, M. E.

Continued from page 170.

Drawing we may consider as divided into pencil-work, inking-in, making centre and dimension lines, figuring, shading and lettering. Having already alluded to pencil-work, we come to inking-in.

Have good ink; without this you will be subjected to continual annoyance, by the washing of lines and the bad working of your pens. To get good ink, go to a first-class house and ask for it; all rules except actual experiment are useless to determine the quality of India ink. The difference in cost between good and bad ink, considering it as part of the expense in drawing, is not a farthing to the sheet, and is fully compensated by the better appearance of the drawing, to say nothing of the convenience and advantage in working.

To prepare ink, ask some one who knows how, or watch some skilled draughtsman. To try it, draw some lines on the margin of your paper, observe their color, how the ink flows, and, after drying, cross them with a shading pencil. If they wash readily, the ink is too soft and not suitable. If it for a time resists the water and washes tardily, it is good. It cannot in any case be expected that an ink soluble in water will resist its action permanently after it is put on the paper. In fact, it is not best that it should, for in shading it is generally desirable to blend and destroy the distinction of outlines by washing.

To fill the pens, wet them, wipe them on the outside, and dip them in the ink, which will rise and fill them by capillary attraction. A good plan is to dip the pen in the water, then blow the water from between the points, wipe the outside, and place the pen with its open side in the ink. It is a better plan than to put the pen in your mouth, and avoids the poison that is sometimes found in fancy colored inks.

Set the pen on end to draw lines; the constant tendency with beginners is to lean the pen to an angle, and drag it on to its side. It must, of course, be held at a slight inclination; but the less the better, if you want sharp lines.

In regard to the use of the T square and set squares, we can give no rules except to observe others, and experiment until you find convenient customs. Be careful of contracting unusual habits, and, above all things, be careful of making important discoveries as to new

plans of using instruments—that custom is all wrong, and that it is left to you to develope the true and proper way of doing things. This is a kind of discovery which is apt to intrude itself at the beginning of an apprentice's course in many things, and often leads him to do and say things which he will afterwards wish to recall.

It is a pretty safe rule to assume that any custom, long and generally followed by intelligent people, is very apt to be right; and, in the absence of that experimental knowledge that alone enables us to judge, it is generally safe to receive such customs, at least for a time, as being correct.

Without any wish to discourage the ambition of the apprentice, which always inspires him to renewed exertion, we nevertheless think it best to caution him against innovations. The estimate formed of our abilities is very apt to be inversely as our experience. Old engineers are not nearly so confident in their deductions as beginners.

A drawing being inked-in, we come next to dimension and centre lines. The centre lines should be in red ink, and pass through all points of the drawing that have an axial centre, or where the work is similar or balanced on each side of the line. This rule is a little obscure, but will be best understood if studied in connection with a drawing, and perhaps best remembered without farther explanation here.

Dimension lines should be in blue, but may be in red. How and where to put them is a great art in draughting. To know where to put them must involve a knowledge of fitting and pattern-making, and cannot be explained here. Of how to put them on, we will say make faint lines, leaving in their centre, when long enough, a space for figures. Study their distribution over the drawing, for the double purpose of giving it a good appearance and to avoid confusion. Learn to make your figures like printed numerals, as they are much better understood by the workman, look better, more artistic, and when learned take but little if any more time than plain figures.

If your scale is feet and inches, write dimensions to three feet in inches, and above this in feet and inches. This corresponds to shop custom, and is more comprehensive to the workman, however it may be wrong according to other standards. In your own sketches and drawings, such as are not intended for the shop, it is suggested that metrical scales be used, because such scales will not interfere with feet and inches, and it will prepare your mind for the introduction of this system of lineal measurement, which is quite sure in time

to be adopted in England and America, as it has been in other places.

In shading drawings, be careful to put on little enough, and to put it in the right place. Many will, and not without good reasons, contend that working drawings need no shading, yet it will do no harm to learn how and where they can be shaded. It is better to omit it from choice than from necessity. Sections must, of course, be shaded, not with lines, although I almost fear to attack so old a custom. It is certainly a tedious and useless one. Sections with light ink shading of different colors, to indicate the material, are easier made and look better. By judicious arrangement of a drawing, a large share of it can be in sections, which in almost every case are the best kind of views to work by. The proper coloring of these sections gives a good appearance to the drawing, and conveys the idea of an organized machine, or, to use the shop term, "it stands out from the paper." In shading sections, leave a margin of white between the tints and the lines on the upper and left-hand sides of the section, it breaks the connection and sameness. The effect is striking, it separates the parts and adds greatly to the appearance of the drawing.

Cylindrical parts in the plane of the section, such as shafts and bolts, should be drawn full and have a "round shade," which, with blue tint on, relieves the sameness of effect, a point to be avoided in sectional views.

Conventional custom has assigned blue as the tint for wrought iron, neutral (or pale ink) for cast iron, and purple for steel. Wood is generally distinguished by graining, which is easily done and looks well.

The title of a drawing is a feature that has much to do with its appearance, and the impression conveyed to the mind of an observer, while it can add nothing to the real value or merits of the sheet; it costs so little to make plain letters, that the apprentice is urged to learn this as soon as he begins to draw, not to make fancy letters, nor indeed any kind except plain block letters, which can be rapidly laid out, and consequently used to a greater extent. By drawing six parallel lines, making five spaces, and then crossing them with equidistant lines, the points and angles in block letters are easily determined; and by a little practice it becomes the work of but a few minutes to put down a title or other matter in drawing so that it can be seen at a distance, or read at a glance in searching for particular sheets.

In the manufacture of machines, there are so many sizes and modifications, that the drawings must assist and determine in a large degree in matters of classification and record. Take the manufacture of machine tools, for instance. We cannot well say, each time we want to speak of them: a thirty-six inch lathe, without screw and gearing; a thirty-two inch lathe, with screw and gearing; a forty inch lathe, triple geared, or double geared, with twenty or thirty foot bed, &c. &c.

Hence, it is necessary to assume symbols for the machines of different classes, consisting generally of the letters of the alphabet, qualified by a single number, that designates capacity, and different modifications. Assuming in the case of engine lathes cited, that A is the symbol for lathes, we have $A^1$, $A^2$, $A^3$, $A^4$, &c., the letter and numerals together making but two characters, to indicate a lathe of any kind. These symbols should be marked in plain, large letters, on the left-hand lower corner of the sheet, so that the manager or workman or any one else will see at a glance what the drawing relates to.

This symbol should run through the time-book, cost account, sales record, and be the technical name for the machine, which should always be spoken of in the works in this manner. In making up time a good plan is to supply each workman with a small slate and pencil, on which he enters his time as so many hours charged to the respective symbols. Instead of interfering with his time, this will increase the workman's interest in what he is doing, and naturally lead to a desire to diminish the time charged to the various symbols. When the symbols are added to the drawing, the next thing is the "pattern numbers." These should be marked, in prominent, plain figures, on each piece of casting, either in red ink or other color that will contrast with the general face of the drawing. These pattern numbers, to avoid the use of symbols in connection with them, must include consecutively all patterns used in the business.

A book, called the Pattern Record, should be kept by the head draughtsman, in which these numbers are set down, with a short description, to identify the piece to which it applies, which can at any time be referred to. Besides this description there should be, opposite these numbers, ruled spaces, in which to enter the weight of the castings, the cost of the pattern, and, if needed, the amount of turned, planed or bored surface it has when finished.

In the same book the assembled parts of each machine should be set down, with its symbol and descriptive name, from which orders for castings can be made, without other reference.

This system is the best one known to the author, and is in substance the plan now adopted in some of our best engineering establishments. It may be susceptible of improvement. He hopes it is; but let the apprentice seize on the idea of system at the beginning. Any plan is better than none, and the schooling of the mind to be had in the acquirement of systematic habits is the great point in view. New plans for promoting system may at any time arise, but they cannot be at any time understood and adopted, except by those who have cultivated a taste for order and regularity.

No branch of engineering work is so largely a question of habit and special rules as draughting, consequently there is no branch of which so little that is useful can be said in the way of instruction. The apprentice's own deductions must be his main guide, and is his surest one; if he first studies the principles that lie at the bottom, such as plane geometry, the laws of force, the object of drawings and their relation to subsequent processes, how far the drawings may influence these processes, the use of the drawings (whether to convey plans to the minds of engineers, or to the workmen who know nothing of the organized machine to which they relate), with many other things that will suggest themselves by practice.

In regard to shaded elevations, I will lay down a simple rule, that is easy to remember, "let them alone until other things are learned."

A shaded elevation that is not well done, although it may surprise and please your unskilled friends, is execrable in the eyes of engineers; and the making of such elevations will give but little if any assistance to other and more important studies at the beginning of a course. Shaded elevations are besides quite superseded by photography at this day, and but few establishments care to incur the expense of having them made. We would not be understood as condemning ink-shading, nor the making of elevations, but arguing the greater importance of other kinds of drawing, which is too often neglected to gratify a taste for picture-making, which has little if anything to do with mechanics.

I now come to note a matter in connection with draughting, to which the attention of the apprentice is earnestly called, and which if he neglects, all else is useless. I allude to indigestion, and its attendant evils induced by draughting. All sedentary pursuits induce this trouble, but none of them can compare with draughting, where every condition in the way of promoting the trouble exists.

The muscles are at rest, circulation is slow, the mind is intensely

occupied, robbing the stomach of its blood and vitality, and, worse than all, the mechanical action of the stomach is arrested by leaning over the edge of the draughting board. I regret my inability to give any fixed rule to avoid this danger, but am at the same time confident that any apprentice who understands the danger can, by his own judgment, avert it by applying some of the logic which we are attempting to introduce into mechanics. We can conclude that if anything tends to induce indigestion, its opposite tends the other way, and will arrest it. If stooping over the board interferes with the action of the digestive organs, leaning back does the opposite; therefore keep your board as high as possible, stand at your work, and cultivate a constant habit of straightening up and throwing the shoulders back. If possible, take brief intervals of vigorous exercise.

Like rating the horse-power of a steam-engine, by multiplying the force into the velocity, we must estimate the capacity of a man by multiplying his mental acquirements into his vitality. Latent power is of no value, neither is latent knowledge nor skill.

Physical strength, bone and muscle, must be one of the elements in successful engineering experience, and a store of these things must be laid in at the same time with our technical learning, or we will find that when we are all ready to enter upon a course of practice we have neglected that most important element, the propelling power.

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## THEORY OF CONTINUOUS BEAMS.

By Jos. P. Frizell, C. E.

(Concluded from page 173.)

By the preceding formula, which first becomes applicable when the number of points at which forces are applied to the beam is not less than three, the force $Q_n$ is expressed as a function of all the forces to the left of it, $Q_0\ Q_1 \ldots\ldots Q_{n-1}$. It will be perceived that by means of this formula applied successively to every opening of the beam, each force Q can be expressed in terms of the first force $Q_0$, which, in its turn, is found by means of eq. (15). Eq. (19) applied to the first opening gives a relation between $Q_0$ and $Q_1$, which, as none of the unknown quantities enter here above the first power, will be of the form

$$Q_1 = B + c\,Q_0 \qquad \text{and, in like manner,}$$

$$Q_2 = C + d\,Q_1 = D + e\,Q_0 \qquad \text{and equation (15)}$$

will take the form

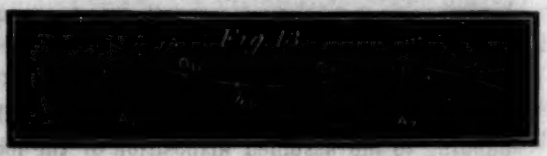
$$(E + F + G + \ldots\ldots)\,Q_0 = (a_1 + a_2 + a_3 + \ldots\ldots)\,w$$

If the width of openings and loading of the beam are symmetrical with reference to the centre, the number of equations can be reduced one-half, in which case eq. (19) will apply to either half of the beam, and the angle $\beta$ will be o for the centre.

It sometimes happens that an end of the beam extends past its supporting point, and is loaded either uniformly or with an isolated weight $Q_m$. For this case $Q_m$ is given and the corresponding ordinate $y_m$ required.

The above method of treating the general case is the one adopted by Dr.* Hermann Scheffler, one of the ablest of modern writers upon this branch of science. In its application to bridge construction it may be extended so as to define the limits of counterbracing in continuous bridge trusses.

If the two inflection points $O_{12}$ $O_{13}$, Fig. 13, could be regarded as fixed, the breaking point $b_7$ would attain its greatest deviation from $A_7$ when the portion $O_{12}$ $b_7$ was uniformly loaded with the greatest allowable load.† The application of this load, however, would move the point $O_{12}$ nearer to $A_6$. That is, it would move the supporting point of the beam $O_{12}$ $O_{13}$. We may, nevertheless, suppose the load to extend from the inflection point to the breaking point. This condition corresponds to the minimum value of the distance $A_6$ $b_7$ so far as that distance can be affected by any disposition of the load between $O_{12}$ $O_{13}$.



An application of load between $A_6$ and $O_{12}$ will cause the inflection point, and consequently the breaking point, to approach still nearer to $A_6$. We conclude, therefore, that a maximum load per linear foot, reaching from $A_6$ to $b_7$, is the condition of a minimum value of $A_6$ $b_7$, so far as that quantity can be affected by any disposition of the load $A_6$ $A_7$.

Again. An application of load in the openings $A_5$ $A_4$ and $A_7$ $A_8$ will have the effect to shorten the simple beam $O_{12}$ $O_{11}$, as indicated at Fig. 9, and will consequently diminish the distance $A_6$ $b_7$.

* Theorie der Festigkeit gegen das Zerknicken nebst untersuchungen über der verschiedenen inneren Spannungen gebogener Körper, &c. Braunschweig, 1858.

† A Short Theory of the Truss. "Journ. Frank. Inst.," Dec., 1871.

It is also evident that the application of load to any alternate opening to right of $A_7$ or left of $A_5$ will have the same tendency as a load in $A_5\ A_4$ and $A_7\ A_8$.

We have, then, for the conditions which determine the minimum value of $A_6\ b_7$ the maximum load applied to $A_6\ b_7$ and every alternate opening to the right of $A_7$ commencing with $A_7\ A_8$, and left of $A_5$ commencing with $A_5\ A_4$, the remainder of the truss being unloaded.

Designating the maximum load per linear foot by W, w representing the weight of the truss per lin. ft., and putting z to represent the distance $A_6\ b_7$, eq. (9) would be written

$$E\,I\,\frac{d^2\,y}{d\,x^2}=\tfrac{1}{2}(a_1+a_2+\ldots\ldots+a_{n-1}+x)^2\,w+(\tfrac{1}{2}\,a_1+a_2+\ldots\ldots+a_{n-1}+x)\,a_1\,W$$
$$+(\tfrac{1}{2}\,a_3+a_4+\ldots\ldots+a_{n-1}+x)\,a_3\,W+(\tfrac{1}{2}\,a_5+a_6+\ldots\ldots+a_{n-1}+x)\,a_5\,W$$
$$+(a_7-\tfrac{1}{2}\,z+a_8+\ldots\ldots+a_{n-1}+x)\,z\,W+\ldots\ldots$$
$$-(a_1+a_2+\ldots\ldots\ldots+a_{n-1}+x)\,Q_0-(a_2+a_3+\ldots\ldots+a_{n-1}+x)\,Q_1$$
$$-\ldots\ldots-(a_{n-1}+x)\,Q_{n-2}-x\,Q_{n-1} \qquad (9\ a)$$

From eq. (9 a) we can deduce eq. (19) with the modifications corresponding to the assumed disposition of the load. This, applied to the several openings, would give finally an equation involving only $Q_0$, z and known quantities. To determine $Q_0$ and z, we should have eq. (15) and a second equation, formed by putting the sum of the values of Q to the right or left of $b_7$, equal to the known weight of the same portion of the beam with its load, remembering that, since $b_7$ is a breaking point, the weight to the right of it falls entirely upon the supports to the right, and *vice versa*.

In this manner we may find the extreme positions of the breaking points for each opening.

It is evident that the simple beams resting at $A_6\ A_7$, &c., require no counterbracing.

However laborious the method may appear, it is not incommensurate with the importance of the object aimed at, viz., a properly constructed continuous bridge. Moreover, since it is not necessary to determine the extreme positions of the breaking points within less than the length of a panel, the method need not be applied to more than two openings of the bridge.

In applying equation (19) to lines of shafting, $a_1\ a_2$, &c., represent the distances from bearing to bearing, or from bearing to pulley, or from pulley to pulley, as the case may be. The unknown values of

$Q_0$ $Q_1$, &c., are the pressures upon the several bearings. The known values are the weights of the several pulleys together with the tensions of the belts respectively driven by them, or the vertical components of these tensions. For every known value of $Q_0$ there would be an unknown value of y, which would determine the deflection of the shaft at that point.

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## BESSEMER MACHINERY.

A Lecture delivered before the Students of the Stevens Institute of Technology by ALEX. L. HOLLEY, C. E.

The manufacture of Bessemer steel, although dependent for immediate improvement chiefly on chemistry and metallurgy, nevertheless furnishes a conspicuous example of the successful development and adaptation of mechanical appliances and processes, and in this regard commends itself to the consideration of students in mechanical engineering.

It is remarkable, 1st, because, in all its cardinal features—although not in many details that have given it commercial success—in all its fundamental features, it was developed, during the brief period of six years, out of nothing, in the way of a kindred and helpful "state of the art," by the remarkable man whose name it bears. Within the sixteen years that have elapsed since Bessemer made his first trials, his process has risen from a nearly abandoned experiment, to the production of a million tons of steel per year. It has, indeed, progressed, as all successful processes do—whether fast or slowly—by the constant aid of experiment and failure; but the rapidity of its development was due, in a degree not often precedented in the iron business, to the genius of its inventor—especially to that form of genius known as perseverance.

2d. The difficulties of the Bessemer manufacture, although great enough mechanically, to require a radically new system of enginery, were not chiefly mechanical. As soon as the engineer had surmounted his obstacle, a chemical stumbling-block rose up in the way; and his discouragement was that absolute mechanical perfection might never lead to commercial success.

3d. The mechanical problems, however, are of an unusually difficult character. The material treated is in a *fluid* state. As a rolling mill man fitly expressed it, "A puddle-ball or a rail pile will lie still on the floor, if anything breaks down; but if five tons of *fluid steel*

gets the upper hand of you, there's no telling where it will *stop.*" Suitably lining vessels to hold and handle the incandescent fluid, involves all the chemical and structural uncertainties of refractory materials. Extraordinary provisions must be made against accidents, and against serious losses, if they do occur. The reserve must be unusually strong, and the line of retreat vigilantly guarded. The excessive heat of fluid, decarburized iron—not less than 4000° Fahr. —and its violent erosive action as it boils in the converter, demand, not only hard and fire-proof linings, but provisions for quickly renewing them; and the impossibility of maintaining the temperature while the metal is being transported and cast, requires great celerity and certainty in these operations; otherwise the metal will chill into mere scrap. In many manufactures, if an important machine fails, a little delay and the immediate repairs are the only loss; but here, constant readiness and certainty of action are indispensable. Ten seconds delay in turning down a converter, when a charge is blown or a tuyere fails, may involve not only the ordinary delay and repairs, but a heavy loss on the product, and extraordinary repairs on, if I may so say, innocent organizations which have been drawn into the general disaster.

4th. The *range* of mechanical engineering involved in the Bessemer process is large, requiring peculiar adaptations of old machines and processes. Besides the ordinary problems of steam engineering, we encounter those of air pressed to 25 lbs. and water to 400 lbs. per square inch, and the utilization of steam power by means of water. In rapidly melting large quantities of iron, and keeping it at high temperatures, the old foundry practice has required enlargement and adaptation. In short, steam and hydraulic engineering, the machinery of combustion, the peculiar enginery of the process, and the adaptation on the grandest scale, of metallurgical chemistry, must be embodied and harmonized in the Bessemer construction and manufacture.

Before considering the process and machinery, let us define the term "steel." Steel is an alloy of iron which is *cast while in a fluid state* into a malleable ingot. Any radical nomenclature founded on chemical differences leads to endless mistake and confusion. If steel is defined as an alloy of iron containing carbon enough to harden it when it is heated and plunged into water, then puddled iron, although laminated and heterogeneous in structure, may be steel, and the finest product of the crucible, although crystalline and homogeneous in

structure, may *not* be steel. The fundamental and essential difference between steel and all other compounds of iron, is a structural difference, and it is always easily determined, while steel and wrought-iron cannot always be distinguished by chemical analysis. The same proportions of carbon, manganese, silicon, and other elements, may exist in and similarly affect any malleable alloy of iron. Steel is, therefore, an allay of iron which is cast into a malleable mass.

The *chemical* part of the Bessemer process, as popularly understood, is the oxidation of the carbon and silicon in melted, crude cast iron, so as to make it malleable, by means of air blasts. This definition to some extent describes puddling, and the earlier processes of making malleable iron. In all these processes the air oxidizes a portion of the iron, and the oxide of iron thus formed undoubtedly oxidizes a part of the carbon and silicon. In puddling, however, the mixture of the oxidizing agent, so that it may come in contact with all parts of the iron successively, is promoted by stirring the melted mass by manual power; but so slow is the process, and so small are the masses that can be treated by a workman, that not even the heat of the combustion thus promoted, nor even the additional heat of the burning coal, can keep the iron *fluid* when deprived of its carbon. The purified iron is withdrawn in a plastic condition, mixed with slag. It requires compression, piling, heating, and recompression to reduce it to a solid bar. The radical and essential difference between this process and the Bessemer process is a *mechanical* difference, and it consists in the *intense and violent stirring* of the Bessemerized iron. To this alone is due the production and maintenance of a temperature, without any other fuel than the carbon and silicon contained, that *keeps the metal fluid*, so that it can be cast into homogeneous, malleable ingots. In puddling, the iron is agitated by the power of one man; in Bessemerizing, it is torn into *spray* by a 500-horse engine. In the one case it is stirred by a single iron bar; in the other, it is pierced by innumerable bars of iron, squeezed solid, like rods of glass, penetrating every part, and enveloping every atom of iron in an atmosphere of oxidizing material. The combustion thus takes place, not in successive sections of the mass, but throughout the whole of it, at the same time, and in the shortest possible time; and the heat arising from *such* combustion has not time to escape from the mass until purification is completed. The quantity of iron that can be treated, in comparison with the mass of heat-conducting surroundings, is also an important feature. The individual reactions are, as far as

we can judge, as rapid and complete in one case as in the other; the fluid condition of Bessemer metal is due simply to the vastly greater number of these reactions, that are compelled to occur in a given space and time, by the mechanical force and distribution of air-blasts.

The Bessemer process as first performed, and as still practiced to a very limited extent abroad, with irons rich in manganese, consists in applying the blast until all but ¼ to ½ of one per cent. of the carbon is burned out, and then casting the product. Stopping the blast at this point, however, is very uncertain; hardly any irons contain the right amount of manganese for this treatment, and the process has certain mechanical objections. Hence the nearly universal practice is to blow the iron until *all* the carbon is exhausted—a point readily determined. But the product now contains so much oxide of iron, that it is red-short and crumbles in working. To reduce this oxide of iron, manganese, which has a stronger affinity for the oxygen than the iron has, is added, by running into the converter 6 to 8 per cent. of melted Franklinite, or spiegeleisen, which is a pig iron containing about 10 per cent. of manganese. One quarter to one per cent. of carbon is also added to the product by the spiegeleisen, so that the result is the same as in the first process, and the convenience and economy are far greater.

No phosphorus whatever is removed from the iron in the Bessemer process, and only 12 to 15 hundredths of 1 per cent. of phosphorus are admissible in steel. More will make it both brittle and unmalleable. Hence the pig iron treated must not contain above one-tenth of one per cent. of this element. The usual percentages of sulphur, manganese, silicon, copper and the foreign elements commonly found in average pig iron are admissible. Suitable ore for Bessemer iron is unlimited in the Lake Superior and Missouri Iron Mountain regions, and it is now developing abundantly in Northern New York, Central Pennsylvania, and at various points in the Southern States.

There is a strong temptation to dwell on the chemical branch of the subject, which can be but very inadequately referred to in a mechanical paper. Enough has been said, perhaps, to explain what *chemistry requires of engineering* in the construction of Bessemer machinery.

It is proposed to consider briefly some of the leading mechanical features of the Bessemer plant; the conditions and principles involved, and the results attained,—to be premised, for the convenience of any

who have not examined the subject, by a short description of the plant as a whole, and of its operation.

A standard American Bessemer plant consists, 1st, of a MELTING DEPARTMENT (Plate I). This is shown in plan,—the ground floor by Fig. 2, the furnace working floor by Fig. 1, and the cupola charging floor by Fig. 3. Sections of these floors, and the furnaces, are shown by Fig. 5. There are hoists at *a* for coal, etc., and at *b* for iron; 4 cupola furnaces and their platforms and blowing machinery; 2 ladles, K, standing on scales, for weighing the melted iron, and spouts, M N, Fig. 5, for conducting it to the vessels, or converters; 2 reverberatory furnaces for spiegeleisen, and their spouts.

2d. The CONVERTING DEPARTMENT, shown in ground plan by Fig. 1, and in cross section by Fig. 5. It contains two 5-ton to 7-ton vessels, N, in which the melted iron is treated by air-blasts. The vessels will presently be illustrated. Also a ladle and a hydraulic ladle crane at E, Fig. 1, by means of which the steel is received from the vessels and poured into the ingot moulds, which stand upon a depressed part of the floor called the pit. Three other hydraulic cranes swing over the pit, to set the ingot moulds and remove and load the ingots. Two of them swing over the vessels, to assist in their daily repairs. The water and air pressure reservoirs are surmounted by a platform, *d*, Fig. 1, standing upon which, boys, by turning valves, admit water to the cranes and air to the vessels, by means of underground pipes. All the constant operations of hoisting, lowering and blowing, are conducted from this platform, which overlooks the entire converting department. The details of these and other parts will be farther described.

3d. The ENGINE DEPARTMENT. This contains a blowing engine, usually a double engine, capable at normal speed of receiving 8000 to 11,000 cubic feet of air per minute, and delivering it at 25 lbs. pressure per square inch. The water pressure pump, for actuating the hydraulic machinery, is a Worthington duplex, with two 25-inch steam cylinders, and two 9-inch water cylinders, 24-inch stroke. The boilers should be capable of 800 horse-power.

The pig iron, having been hoisted to the charging platform, is put, with 20 per cent. of coal, into one of the cupolas, and melted. When say 12,600 lbs. have run into one of the ladles, K, the latter is turned over by means of a worm wheel, thus pouring the iron into the spout which leads it to one of the vessels.

Before following the iron through the converting process, let us

# AMERICAN 5 TON BESSEMER PLANT.

**Product 100 tons per 24 hours**

Fig. 1.

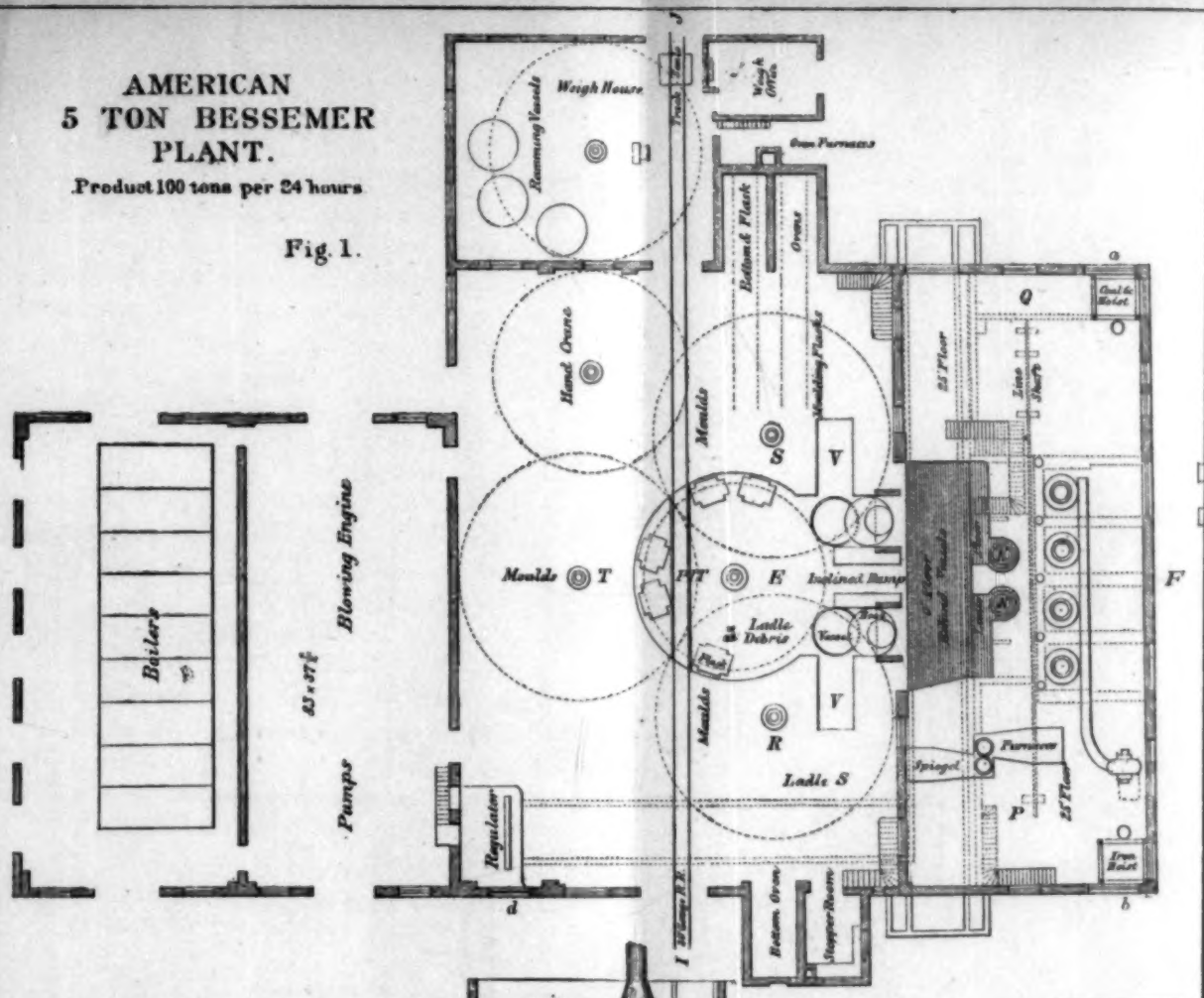



Fig. 5.
*Section on E.F.*

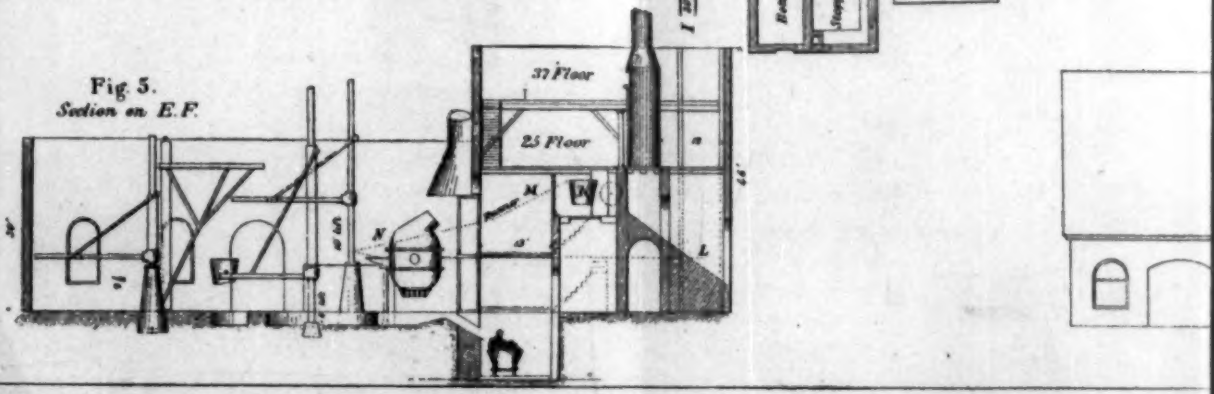
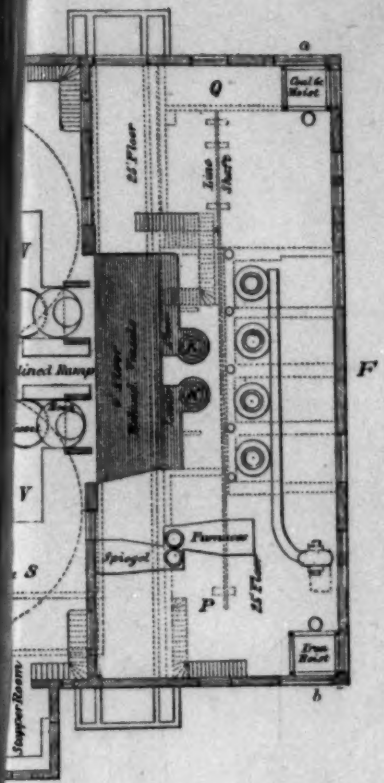


Fig. 2.



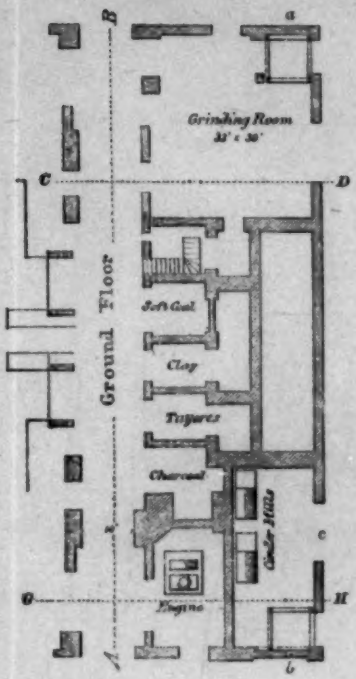




Fig 3

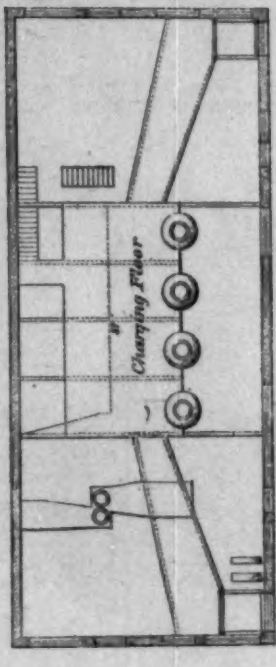
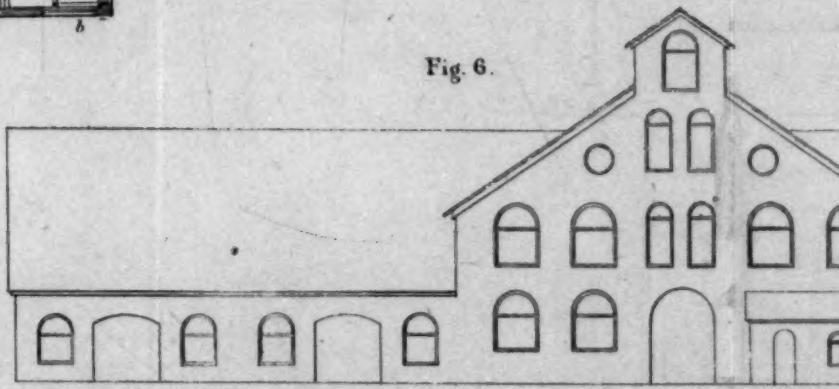



Fig. 6.



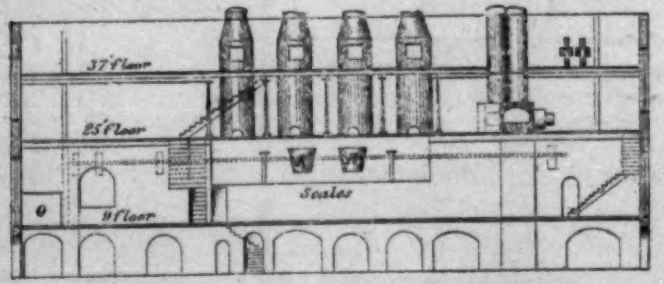
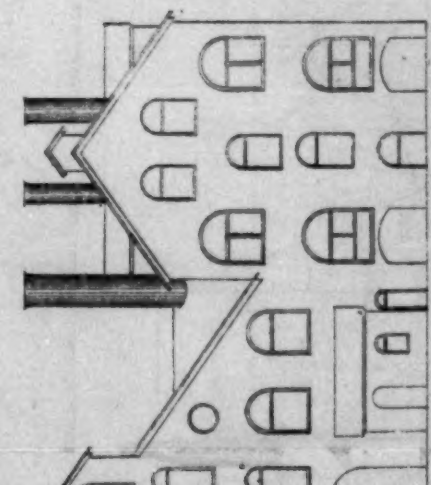



Fig. 4 Section at A B



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glance at the construction of the vessel, the simplest form of which is shown at A, Plate II. A vessel that will convert a 5-ton charge is 8½ feet in external diameter, and 15 feet high. It is made chiefly of ½ in. to ⅝ in. iron plates, and lined nearly a foot thick with refractory material. At one end it has an 18-inch opening, called the nose; at the other a tuyere box, *a*, Fig. 2, communicating with the blowing engine. From the tuyere box, 12 fire-brick tuyeres, each perforated with twelve ⅜-inch holes, project through and are embedded in the lining. A tuyere is shown in section by Fig. 1. These tuyeres last but 6 or 8 heats, and are arranged, as we shall see farther on, to be rapidly renewed. The vessel is mounted on trunnions, and turned by a hydraulic cylinder, by means of a rack and pinion. When the charge enters, the tuyeres are turned up as at Fig. 3, so that the iron will not run into them. The blast is then admitted, and the tuyeres turned down so that the metal will flow over them and be pierced by the entering columns of air. The cubical contents of the vessel is 8 to 12 times that of a charge of iron, in order to give room for ebullition. The vessel lining is heated red-hot and the fuel discharged before the iron is turned in.

The iron is now subjected to 120 streams of air, ⅜ of an inch in diameter, at 15 to 25 lbs. pressure, for about 20 minutes. Most of the silicon is first burned out, the result being slag, and a comparatively dull flame at the converter mouth. When the carbon begins to burn freely, the volume and brilliancy of the flame increase, and as the surging mass grows hotter, and boils over in splashes of fluid slag, the discharge is a thick, white, roaring, dazzling blaze, and the massive vessel and its iron foundations tremble under the violent ebullition.

Towards the close of the operation the flame becomes thinner, and when decarburization is complete, it suddenly contracts and loses illuminating power. The determination of this period is the critical point of the process. Ten seconds too much or too little blowing injures or spoils the product. At the proper instant, as determined best by the spectroscope, or by colored glasses, but usually by the naked eye, the foreman turns down the vessel and shuts off the blast. The charge of melted spiegeleisen is then run in, when another flaming reaction occurs. The vessel being still farther depressed, the steel runs into the ladle, pure, white and shining, from under its coating of red-hot slag. A blanket of slag, most useful in preserving its temperature, follows it into the ladle. The metal is now let into the

ingot moulds, by means which will be farther illustrated. After the exterior surface of the steel has crystallized, the mould is removed, and the ingot is ready for re-heating and rolling.

Having thus taken a general observation of the Bessemer plant and process, we are prepared to analyze the peculiar mechanical requirements, and the way in which they have been met.

This subject divides itself under two heads:

1st. The *cardinal requirements* upon which hinge the production of steel at all, whether fast or slowly, expensively or economically.

2d. The *mechanical refinements*, upon which commercial success depends.

The most novel and difficult problem obviously was, how to hold and handle fluid iron while it was being treated with violent blasts of air, and how to do this with such celerity that the metal would *remain* fluid. The American experiments of Kelly, which antedated those of Bessemer, were successful only to a limited extent, because these conditions were not fully met. He blew air downwards into the metal, at low pressure, and in few and large streams; hence his iron chilled before decarburization was complete. His crude method of handling the metal increased this difficulty. Bessemer first treated crude iron with air blasts in a crucible set in a furnace, and thus maintained its fluidity. But the cost of this outside heating, the smallness of the product, and the difficulty of applying the blast and maintaining the blast-pipe, rendered the process abortive. Nor was this what we now know as the Bessemer process, for that, as we have observed, hinges upon the generation of the heat from the fuel *contained in the iron.*

The first *radical* feature of the Bessemer apparatus was imbedding the tuyeres in the lining of the vessel; or, in other words, the perforation of the bottom part of the vessel lining. The bottoms of the tuyeres (A, Plate II) are luted with plastic clay, inserted in openings in the tuyere box grooved to hold the luting, so that no air can leak by, and held in place by a dog (Fig. 1). Semi-plastic refractory material, chiefly ground silicious stone, is then rammed between and around the tuyeres, thus forming the continuous lining of the vessel.

This feature is essential, *first*, to the maintenance of the tuyeres. It is obvious that a naked refractory tube, projecting into the molten metal, with iron and slag alternately wearing and chilling on all sides of it, is far more costly to construct, operate and maintain than the mere end of a brick block lying flush with the lining, and that any

apparatus to insert and withdraw a tuyere, must be expensive and easily deranged by the heat and splashes, while the perforated bottom requires no moving apparatus additional to that which rotates the vessel.

*Second.*—The perforated bottom—the introduction of the blast *beneath* the iron and in numerous jets, is essential to its violent and distributed agitation.

The second radical feature is the *rotating* vessel. The very limited use of a stationary vessel having similar tuyeres has been referred to; but as recarburization cannot be performed in such a vessel, and as it is otherwise impracticable for a maximum production, we may properly omit its consideration. We have already observed the value of the rotating vessel in placing the tuyeres under the metal to blow, in removing them to stop blowing, in receiving the iron from the cupolas, and in pouring the steel into the casting ladle. To assure ourselves of the simplicity and perfect adaptation of this means to these ends, we have only to try to imagine an inadequate substitute. If a tuyere fails while blowing, as is often the case, at the first indication, the perforated bottom is turned up out of the metal, where it can be reached and repaired. The defective tuyere is cut out, the hole is rammed full of moist clay and sand, and the blowing is resumed with the remaining tuyeres after 5 or 10 minutes' delay. Three or four of these "dummies" are sometimes inserted without reducing the day's product. If the tuyere of a stationary vessel fails, the whole charge burns through the bottom, causing serious delay and loss.

*Third.*—The tuyere-box is an important part of this system. It forms a common blast reservoir for all the tuyeres, the air being brought to it from the regulator through the hollow trunnion of the vessel. By breaking a single joint—that is to say, by removing the tuyere-box cover—either of the tuyeres may be examined and removed.

One of the neatest of Bessemer's minor inventions is the air-space (*c*, Fig. 1) left between the top of the tuyere-box and the bottom of the vessel. 1st. If any blast leaks by a tuyere, it escapes into this passage instead of cutting a channel clear through the lining alongside the tuyere. 2d. If a tuyere burns down too short, the sparks escaping through this air-space apprise the workman in time to turn down the vessel before serious damage is done.

*Fourth.*—The *shape* of the vessel is an important feature. The interior is well formed for resisting wear, for thorough agitation and

for the preservation of heat. The nose is equally convenient for charging and discharging the metal, and for discharging the gaseous products of combustion into the chimney. The angular position of the nose gives the vessel so large a capacity when lying on its side, that the whole charge will lie in it without running either into the tuyeres or out of the nose. We can hardly see how the shape can be improved, or how any other would be admissible. In its general features it was the first, and as here presented it was the second vessel patented by Mr. Bessemer.

*Fifth.*—The Ladle-Crane (B, Plate II) is another radical departure from the nearest kindred practice. The ladle, instead of swinging from a crane-chain, as in a foundry, is rigidly held in a fixed orbit. This feature was original with Bessemer, and to it he added the old ladle with a pouring nozzle in its bottom, regulated by a movable stopper (B, Figs. 1, 2). This consists of a loam-coated rod, *a*, armed at its lower end with a round-ended, fire-brick or plumbago stopper, fitted to the concave top of a fire-brick nozzle. The stopper is raised and lowered by a lever, *e*, in the hand of the workman. Thus the heavy steel is discharged pure, while the lighter slag and impurities are left at the top. Pouring steel into moulds over the rim of a ladle, as in foundries, would make excessive scrap from spilling and chilling, and is wholly impracticable. The vertical motion of the crane is necessary in pouring from the vessel, to keep the ladle close under the nose, thus preventing too great a fall of the stream and consequent slopping. The ladle is also tipped by a worm and worm-wheel, *h*, to regulate the position of the nozzle over the moulds, and to turn over the ladle for heating and repairs.

While this drawing is before us, let us observe several features that have been added later, in this country. 1st. The radial motion of the ladle, by means of a rack or a screw, *i*. This is necessary to adjust the stream vertically into moulds standing in different positions; and it is convenient in properly placing the ladle under the vessel nose.

2d. The accurate adjusting of the stopper in the nozzle, by means of a hinged plate (Figs. 1 and 2) to which the stopper, slide and lever are attached.

Plate II, C, shows the English ladle crane. The ram has no top support. The jib revolves on friction rollers, and the weight of the ladle is counterbalanced.

The details of construction will be further referred to.

A

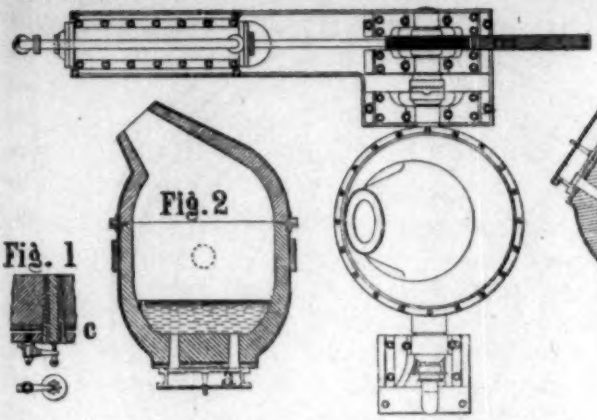



Fig. 3.

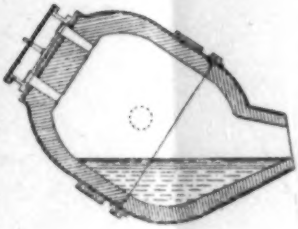


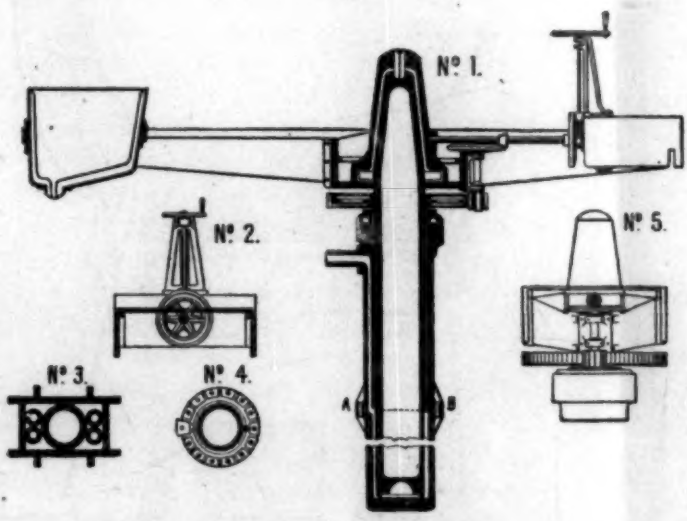
Fig. 1

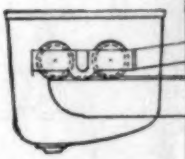
DRAWN BY S D. GRAYDON,

CLASS OF 1875.

*Stevens' Institute of Technology.*

C



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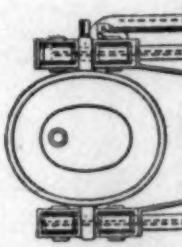
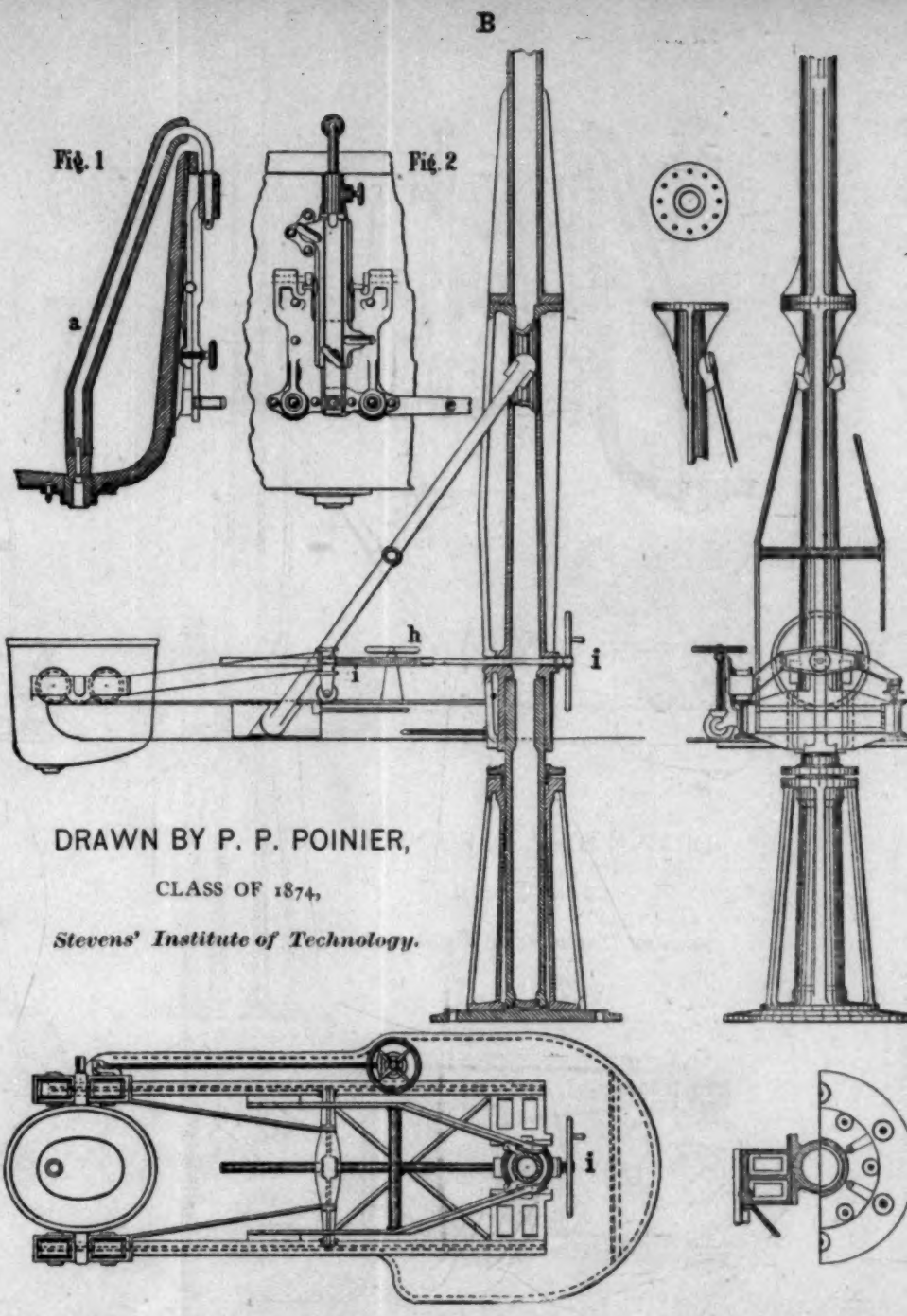





DRAWN BY P. P. POINIER,

CLASS OF 1874,

*Stevens' Institute of Technology.*

D

Fig. 1.

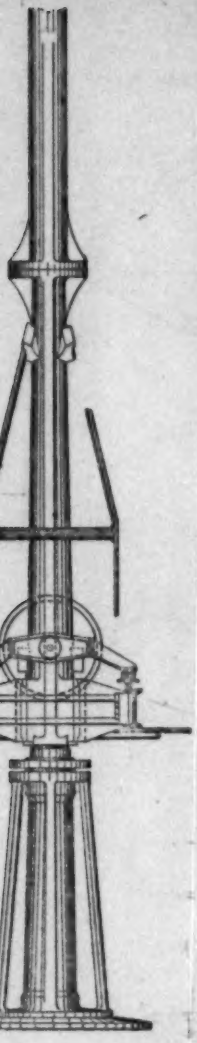
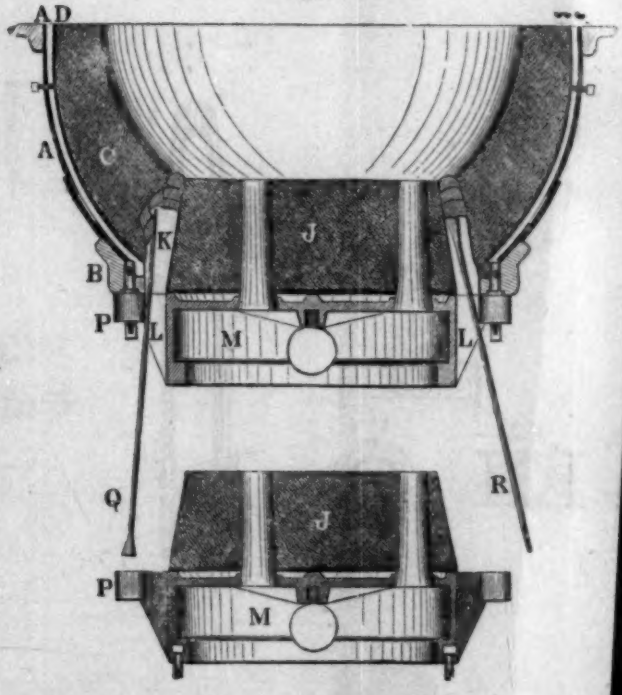


Fig. 2.



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These are the cardinal requirements; but these alone would not have made the manufacture a commercial success in this country, by reason of the greater cost of materials and labor, and the inferiority of the refractory materials yet discovered. Let us now glance at the mechanical refinements.

A very large and regular product is essential to commercial success. The same engine and boiler capacity, the same vessels and accessories, the same quality and nearly the same extent of hydraulic machinery, melting apparatus and buildings are required—in all, say $200,000 worth of plant—to make 6 five ton heats per day, as to make 16 five-ton heats per day. Six heats was the maximum work in England three or four years ago, and still is in some foreign works, ten or twelve being the average abroad,—while 18 to 24 heats are the standard practice in America. This additional work, got out of nearly the same capital, is the result of these mechanical refinements. A forty thousand dollar blowing engine must be *kept at work*, to pay dividends, in this country at least.

It is true that a small plant can be built at a quarter of the cost named, with a proportional maximum capacity; but the peculiarity of the Bessemer business is, that such an establishment cannot be run at a profit. The cost of fuel is greater, and the cost of labor is twice or thrice as much *per ton of product* as in the large works. In some other manufactures the case is different. A single Siemens-Martin furnace is a complete plant, and can be run with comparative economy. In the present state of our knowledge of refractory materials, a 5 to 7 ton plant, capable of producing 100 to 140 tons of ingots per 24 hours, would appear to be the most economical.

In order, then, to crowd Bessemer machinery up to its maximum production, its strength and durability must be implicitly relied on. No weakness, irregularity or inefficiency can be tolerated. The failure of one little part may involve a whole system of machinery in costly delays and extensive repairs. As we have observed, a breakdown in some other manufactures is not so serious.

It would be interesting, if we had time, to compare the early proportions of Bessemer machinery with those developed by practice. In iron and steel machinery, generally, there seems to be required an extraordinary amount of mass, solidity and strength, to insure *smooth* as well as uninterrupted working. Yet nothing need be clumsy. No sudden blow, or violent stress, or prolonged strain, can ever be set up as a reasonable excuse for the violation of even the artistic feeling in engineering construction.

The *duplication* of certain parts is another element in maximum production. Not even the best we can do in the way of proportion, workmanship and strength of materials, is a sufficient insurance against delays.

Two vessels are simply indispensable. If a set of tuyeres will only endure 4 to 6 heats, and a new set, together with its section of vessel lining, must be put in, dried, and thoroughly heated before it can be used, it is easy to see that getting 18 heats per day out of *one* vessel is beyond the present capacity of refractory materials.

A double blowing engine—that is to say, two engines connected, has usually been preferred, but is not indispensable to uniform blast. Two *dis*connected engines, however, as first used at the Cambria Steel Works, in Pennsylvania,—each engine large and strong enough, in an emergency, to blow a heat—give the advantages of the double engine, and prevent delay in case one engine is disabled. Nor is this all. Merely blowing say 20 heats occupies but 10 of the 24 hours, yet the engine must run 10 or 12 hours besides this, at reduced speed and pressure, to heat the vessels. Using one of the disconnected engines, instead of the whole of a double engine, for this purpose, saves much steam and wear.

The pressure pump, for actuating the hydraulic machinery, is the heart of the Bessemer system. If the heart stops, trouble is serious and immediate. Two pressure pumps—excellent as is the kind employed in this country—the Worthington duplex—are deemed essential to maximum capacity. Two cranes are necessary to reach over the two vessels; three are indispensable to a product of 80 or 100 tons per day. Three cupolas are necessary to give time for the repairs of their linings, although but one is run at a time. Four are used in the latest plants. Two spiegel furnaces are employed for the same reason.

This and some farther duplication of machinery is essential, not only to continuous working in case of breakdowns, but to the simultaneous conduct of manufacture and repairs.

Akin to this topic is the *arrangement* of fixtures and machinery, with reference to economical working, which will be farther considered.

It will have been observed that in handling melted iron and steel on this grand scale—handling it so carefully as to prevent spilling, and so rapidly as to avoid chilling—requires not only strength of parts, but great steadiness and celerity in the operations, and abso-

lute control of them by the workmen. This almost necessarily involves the use of *hydraulic* machinery. A steam hoist—a simple cylinder and piston—is wholly inapplicable, by reason of the elasticity, condensation and consequent unsteadiness of the steam support. A steam hoist geared, to overcome this difficulty, is liable to be disabled by heat, splashes of slag and metal, and showers of sand. Nothing can be more simple and permanent than a massive hydraulic cylinder and ram. Water, being practically unaltered in volume by any temperature or pressure to which it is here subjected, its motion can be controlled with the utmost nicety, and its staying power, when placed, is like that of a cast-iron column.

Having thus observed the general conditions of a maximum product, it remains to consider some of the more important details of construction and refinement.

The difficulty of repairing the refractory linings, especially the vessel bottom, which lasts only 4 to 8 heats, was for a long time the weak point of the Bessemer system.

The early method of setting tuyeres was knocking out the stump left from the denudation of the bottom, and inserting a new tuyere from the tuyere-box. The vessel being too hot to enter for 20 hours or more after a blow, for the purpose of filling and ramming the space around the tuyeres, this space could only be filled by pouring semi-fluid refractory material into the nose of the vessel, and letting it set as best it might by the evaporation of the water. The bottom was thus porous, and, unless long heated, it was damp. The constant breaking through of the steel was the result.

Mr. Bessemer then devised the duplicate bottom (D, Plate II), consisting of a tuyere-box, tuyeres and section of lining, previously rammed and dried. The old bottom, with its tuyere-box, was withdrawn bodily, and the new one inserted. This was a vast improvement, but still the annular space around the new bottom had to be filled with a semi-fluid material, just like the space around the individual tuyeres in the old practice; or else the vessel had to stand idle a long time to cool, so that a workman could enter it and ram the joint.

After a good deal of experimenting, the simple expedient was arrived at in this country, of so constructing the lower part of the vessel, as shown at D, Figs. 1, 2, that the annular space can be rammed from the *outside*, with bricks or cakes of semi-plastic material. The method of inserting this filling, by means of the rammers, Q R, into the annular space, K, between the new bottom and the vessel lining, is

shown in Fig. 2. The filling is then covered with the plates, N, Fig. 1, which are cottered on; after half an hour's heating the vessel is ready for use. A new, dry and trustworthy bottom can now be made in two hours from the last blow on the old bottom, so that one vessel is always ready. Six interchangeable bottoms are employed for two vessels. This seems a small detail, but it has been the chief cause of raising the product of American works from 10 and 12, to 18 and 24, heats per day, and it has nearly done away with what was sometimes of daily occurrence in the old practice—the bursting through of the fluid metal, often so suddenly and on such a scale as to render temporary repairs impossible, so that the whole charge was made into scrap.

The lining of the vessel other than the bottom, with the best American refractory materials yet employed, endures 400 to 500 heats. The best English materials last twice as long.

The English vessel lining is a hard sandstone, called "ganister." It contains about 93 per cent. of silica, 4 per cent. of alumina, 1 or 2 per cent. of oxide of iron, and often a little soda, lime, potash, &c. It is a true quartzite. This is ground into sand and dust, and mixed, sometimes, but not always, with a little fire clay while being ground. It is then wetted to a semi-plastic consistency, and rammed into a solid wall, between an iron mould temporarily inserted and the shell of the vessel. The hardness and uniformity of the ramming is of special importance. The lining is at first slowly dried, and then glazed by filling the vessel half full of coal, and blowing for four to five hours at two or three pounds pressure. The vessel is then ready for use.

In this country, no stone exactly like ganister has yet been found. We use any hard, dense sandstone or any quartz, mixed with ten or twelve per cent. of ground fire clay. The chemical composition of many of these stones is similar to that of ganister, except that they contain a little less alumina. The *natural mixture* of the small amount of alumina in ganister, appears to give the mass a degree of density and cohesion, both wet and dry, that can hardly be obtained with three or four times the amount artificially mixed. Too much alumina is *chemically* eaten away; this is why tuyeres fail so soon. A fire-brick vessel lining, though hard enough to stand the abrasion of the surging mass, would be chemically destroyed in a very few heats. Silica, on the contrary, although refractory enough, is soon *washed* away, because it will not fuse into a dense mass. The me-

chanical structure of quartzite has an important bearing on its endurance when rammed into the vessel. The heat of successive charges compacts and hardens it. This is still an unsettled problem, requiring mostly chemical aid.

In order to place the moulds in the vessel so that the lining material can be rammed around them, the vessel must be taken apart. The means of doing this will be further referred to. In foreign works, the vessel is divided near the centre; each section is turned with its larger opening upward, and separately rammed. The two are then put together with a luting of fire clay. The whole operation occupies 36 to 48 hours. The American plan, just being introduced, is that of duplicate top, bottom and nose sections, which are previously rammed and dried. The centre section, being more difficult of removal on account of the trunnions, is rammed in its place. The time lost in lining is thus brought down to about twelve hours.

(To be continued.)

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## BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 177.)

Mr. F. W. Bacon sends me the following two cases: "A 12″ cylinder, 36″ stroke engine, running 66 revolutions per minute, with 10 ft. fly-wheel pulley, drives a 6′ 6″ pulley, 19 ft. horizontally away and 8 ft. above the engine shaft; both pulleys of iron, smoothly turned. Over these passes a 14″ single leather belt, with strips 2″ wide secured to each edge of the outer face; top fold of belt sags 20″ from the straight line between pulley surfaces. The belt is about 80 ft. long, and was dressed with castor oil when started; has been running 4 months, does not slip under heaviest load, adheres closely to pulleys, even at the edges, owing to the increased tension put upon the belt by the strips. The engine indicates 35 to 40 horse-power. At 40 it gives 60·475 square feet of belt per horse-power per minute.

"Another case which may be of interest is that of a belt 12″ wide, 68 ft. long, stripped at the edges like the above; is driven by a 53″ diameter pulley, unturned, around two pulleys on a vertical shaft, thence to a 40″ diameter smooth-turned pulley at right angles to the driver, which makes 101 revolutions per minute. The work done is from 25 to 30 horse-power. The belt is dressed with castor oil, and is ample; at 30 horse-power it is 35·256 square feet of belt per minute per horse-power."

I have the case of an 18-inch diameter by 36-inch stroke horizontal steam-engine, running 60 revolutions per minute, and indicating 77 horse-power. It has a 12 ft. pulley fly-wheel, over which runs a 14½-inch, much used, double leather belt. This belt drives a 5 ft. pulley, the centre of which is 24½ ft. from and 10½ ft. above the centre of fly-wheel; the lower fold draws, and the belt runs quite freely without slipping. These figures give a velocity of surface equivalent to 35·5 square ft. per horse-power per minute.

*Comparison of Single and Double Belt.*—A 34-inch pulley on a line shaft running 200 revolutions per minute drives a 44-inch pulley on a grindstone shaft. The grindstone is 72 inches diameter, its shaft nearly on same level as line shaft, and 7 feet 4 inches away. About midway between these pulleys, a 10-inch diameter tightener, weighing 90 lbs., rests upon the top fold of belt, bearing it down 14 inches from straight line of pulley faces. This tightener is carried by a horizontal swinging frame, having radius arms 4 feet 6 inches long. A 7-inch *single* leather belt, of best make, was completely worn out in four months, another lasted seven months, while a 7-inch *double* oak-tanned leather belt lasts about four years.—*Samuel Bevan, at Henry Disston & Sons, Keystone Saw Works, Philadelphia.*

A horizontal "Corliss" engine, having a 23-inch by 48-inch cylinder, making 52 revolutions per minute, has an 18 ft. fly-wheel pulley; upon this runs a double leather belt, 28 inches wide and 80 feet long, driving a 6 ft. diameter pulley, whose centre is about 18 feet horizontally distant, and whose bottom face is about on a level with the top of the fly-wheel pulley face; both pulleys of iron, smoothly turned.

The lower fold of belt drives; the top fold runs quite freely, with considerable sag.

The maximum load of engine is 217 indicated horse-power, the minimum about 150. These figures give 31·6 and 45·75 square feet of belt per minute per horse-power, respectively.

"Peter McIntosh & Sons, Glasgow, call attention to their machine-rivetted strapping, rivetted with copper or iron wire. This new joining is highly recommended, being much stronger than hand-sewn, and specially adapted for double strapping."

Messrs. Alexander Bros., of this city, say: "We find the average

permanent stretch of oak-tanned leather belting to be about ·725 in. per lineal foot, or as follows:

"Average stretch of back pieces per foot, ·562 inch.
" " middle cuts " ·75 "
" " lower edge " ·875 " "

At Druid Hill, Baltimore, Md., a Babcock and Wilcox engine turns a 28 ft. pulley fly-wheel, lagged with wood, 52 revolutions per minute, carrying three single leather belts, each 16 inches wide, and developing 500 horse-power, which equals a belt transmission of 36·6 square feet per minute per horse-power; velocity of belt 4579 feet per minute.—*G. H. Babcock.*

*Cement for either Leather or Rubber Belts.*—"Gutta percha, 16 oz.; India-rubber, 4 oz.; pitch, 2 oz.; linseed oil, 2 oz. Cut the rubber in shreds and add the oil, which in a few days will have softened the former. Melt carefully the gutta percha and pitch together, and stir in the rubber solution or paste. Apply hot to and press the joints." —*E. H. H., in Sci. Amer., Aug.* 26, 1871.

"If two shafts in the same plane, but not parallel, are belted together, the belt will run towards the ends which are nearest."

"According to my observation and experience, a running belt, nearly vertical, will run to the highest side; but belts running nearly at an angle of 45° to horizontal, will run to the end of the pulley where the shafts are nearest together, the pulleys in both cases being straight-faced."—*B. P. G. Mass, in Sci. Amer., Aug.* 12, 1871.

*To Lace a Quarter-Twist Belt.*—"Put the belt on, and bring the ends together in the usual way; then turn one end inside out and lace. The belt will run, it will be found, first one side out and then the other, and will draw alike on both sides."—*W. H. K., N. Y., in Sci. Amer., Jan.* 14, 1871.

"The theory of cone pulleys is a complicated and difficult one, one element in the solution of which is the distance between the axes of the pulleys; and it is only when this distance is very great in comparison with the diameter of the larger pulley, or when the two pulleys are nearly of the same size, that the rules commonly given will apply. If belts were made of some inextensible substance, the difficulties of adjustment would require more accurate rules; but, fortunately, leather belts readily accommodate themselves to slight errors of construction, although not running in such cases with equal tension."—*Nemo, Canada, in Sci. Amer., Sept.* 9, 1871.

Cone pulleys, "consisting of a series of pulleys of different diameters, generally formed in one casting, fixed in one order of succession on the driving shaft, and in the reverse order on the driven, the proportion of the respective diameters of each pair being such that the sum of the two is always constant, so that the same length of belt will do for all the speeds."

"We were first led to question the orthodox saying, that belts always run to the high side, when putting up some cones about 6 ft. long, 22 in. diameter, at one end, and 11 inches at the other. They were straight cones, placed about twelve feet apart from centre to centre; broad end of the one turned to the narrow end of the other. When the belts were put on, to our surprise, they tended to run to the high end of the one and to the low end of the other."—*J. W. H., in Sci. Amer., July* 29, 1871.

"A 24-inch diameter iron cylinder, nearly horizontal, has a stream of bone black running constantly through it at a temperature of 350° Fah. This is caused to revolve by a 7-inch wide gum belt, applied directly to the naked cylinder, and lasted just three months. The cylinder was used 20 to 22 hours in the 24. Before applying the next belt the cylinder was lagged with wood 1 inch thick; two months of use showed no appreciable deterioration of the belt.

"In our refinery gum belts do better than leather in hot and in damp situations, and in places where they are subjected to the combined influence of heat and moisture.

"Single leather belts seem to be more economical than double ones in places pregnant with sugar and bone black dust. Double belts stiffen and crack, then the pores become filled, and dubbing does not relieve them, but forms with the dust a glazing on the surface.

"Single belts are not likely to become so unpliable, and therefore hug the pulleys better, and work *more than half* as long as double belts. Gum belts make better elevators than double leather belts.

"Our belts are generally put *flesh side* next the pulley; have had some put *hair side* next the pulley, which we prefer, believing the adhesion is greater, and have not observed any less liability to crack when so used.

"In our 'Mill Room,' where there is much sugar dust but no great heat, if we keep the belts dry, they work and last well; while in the 'Black' rooms, where there is high heat and dust combined, belts are short lived."—*Dr. H. M. Howe, Franklin Sugar Refinery, Philadelphia.*

# Chemistry, Physics, Technology, etc.

## FLUORESCENT RELATIONS OF ANTHRACENE AND CHRYSOGEN.

By Henry Morton, Ph. D.,
*President of Stevens' Institute of Technology.*

Anthracene, which has excited so much attention of late by reason of the successful manufacture from it of artificial alizarin, heretofore only found in madder root, and yielding one of the very best red dyes, has been largely studied, but chiefly from a chemical standpoint; and thus there is room to hope for novelty in presenting the results of some observation which I have recently made on certain of its optical properties.

This substance is found in the roofing pitch run out of the retorts of the coal tar distillers, and occurs in commerce as an olive green fused mass, a grey green scaley powder, or, as imported from several German chemical manufacturers, under the name of chemically pure anthracene, as a dirty white or yellow brown powder.

In all these conditions, except in the pitch, if it is placed in a beam of sunlight which has passed through a solution of ammonio-sulphate of copper, it yields a very characteristic spectrum, indicated in Fig. 1, consisting of four bright bands, the first red, the second orange, the third and fourth green, separated by dark shades.

Fig. 1.

This spectrum is found alike in a great number of samples obtained from foreign manufacturers, and also in some very fine ones kindly furnished me by Mr. Cheene, the superintendent of the large works of Messrs. Page, Kidder & Co., at Bull's Ferry, N. J., as also in numerous samples which I have prepared by distillation, solution and like treatment, from these materials. Among all of these, varying in color from olive green to light straw-yellow, pearly scales, the same fluorescent spectrum is seen.

It therefore comes to be an useful practical test for this substance.

In La Lumiere, Vol. i, p. 382, Becquerel describes the spectrum of a hydro-carbon having the color of the uranium salts, which he had obtained from Fritzsche (who first studied anthracene). He gives no measurements of its bands, but only a drawing showing their relation to the Fraunhoffer lines. Comparing this with my own observations (see Fig. 1), there seems to be an agreement as close as the method of representation would admit, and quite as close as exists in the case of two uranium salts, whose spectra he also figures.

It seems legitimate, therefore, to conclude that the substance with which he experimented was identical with the anthracene of commerce.

While writing the above, I received the last number of Poggendorff's Annalen, 1872, No. 7, and there find the remarks by E. Hagenbach, on the above subject, in which he states that his examination of a minute fragment of photene or anthracene obtained from Wöhler leads him to the conclusion that it differs from that used by Becquerel. His measurements for the bands are also unlike mine.

As, however, I find a perfect agreement in the position of these bands in specimens of anthracene obtained from several foreign and American sources, and in all sorts of conditions resulting from various treatment, it seems to me clear that Hagenbach's fragment is not a specimen of the body now known in commerce as anthracene.

The next question that presents itself is this: Is this spectrum due to anthracene itself, or to some intimately associated body?

To settle this it was necessary to obtain some chemically pure anthracene. Kopp, who has just published an extended research on this subject (see note below), recommends distillation after crystallization from hot alcohol.

This, however, not yielding in my hands a material pure enough for the very delicate optical test employed, the following method was adopted: The saturated hot solution in alcohol was allowed to cool to say 80° or 100° F., and to deposit a first crop of crystals in so doing. These were removed by filtration, and then, on further cooling, a second and much finer crop was obtained.

By such treatment we at last obtain a mass of perfectly white,*

* Kopp curiously says in one place (see Le Moniteur Scientifique, Quesneville, 1871, p. 536): "L'Anthracene chimiquement pure est crystallin d'un blue éclatant lamelleme," &c. While elsewhere he says, p. 535, "L'Anthracene parfaitement pur est incolore." This last statement is undoubtedly the correct one.

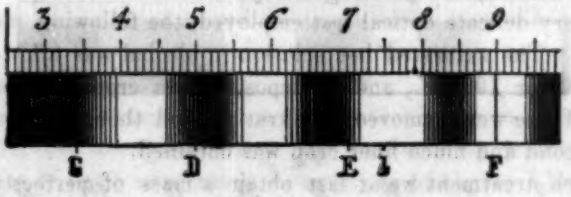
pearly flakes, which fluoresce of a light blue, and show bands identical with those already studied, only much less distinct and brilliant. This appearance leading me to suspect that an impurity was still present, I exposed some of this white anthracene, in solution in hot alcohol, to sunlight, Fritzsche having noticed that sunlight decomposed one of the most persistent impurities (*i. e.* chrysogen) and Kopp recommending the same treatment. I thus obtained a white body crystallizing in scales and in all other properties identical with the white anthracene just described, except that it fluoresced very faintly and yielded a spectrum without any bands. Numerous tests showed that this substance was not para-anthracene. It would thus appear that absolutely pure anthracene is not distinguished by the brilliant blue or violet fluorescence which has been ascribed to it by all authors, but that this property, as also the spectrum above described, as well as that noticed by Hagenbach, belongs to an adherent impurity.

Fritzsche gives the name "chrysogen" to the yellow coloring matter, which adheres with extreme tenacity to the anthracene; is soluble in ether, and is destroyed by exposure of the hot benzine solution to sunlight.

This is without doubt the substance whose spectrum is found in all the forms of anthracene first enumerated, and in the material examined by Becquerel, and of which a quantity, too small for analysis, was isolated by Fritzsche (see Comptes Rendus, T. liv, p. 910).

In addition to the *fluorescent* spectrum furnished by impure anthracene, or rather, we should say, chrysogen, it gives a very characteristic absorption spectrum, showing two strongly marked bands, a less defined one, and a total extinction of all rays above 12·8 (see Fig. 2).

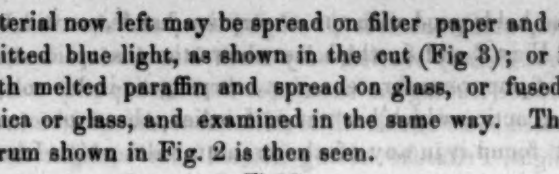
Fig. 2.




To obtain this it is best to distil some of the crude green anthracene in a current of air (see Chem. News, Vol. 25, p. 165) at a rather high temperature, so as to get a yellow product; then to wash this thoroughly with cold alcohol, which removes a brownish-yellow material, yielding no absorption bands, and little, if at all, fluorescent.

The material now left may be spread on filter paper and examined by transmitted blue light, as shown in the cut (Fig 3); or it may be mixed with melted paraffin and spread on glass, or fused between slips of mica or glass, and examined in the same way. The absorption spectrum shown in Fig. 2 is then seen.

Fig. 3.




The band near 9 of scale or F, encroaches on the upper bright band of the fluorescent spectrum, so that in certain methods of observation, when absorption and fluorescence are observed at once, this bright band seems to be narrower than the one next below, which, however, is not the case.

The bands about 13 of scale or G, is not well defined, and is connected by a shade with the point about 14, where the absorption becomes total.

The imported chemically pure (?) anthracene, washed with alcohol to remove a brown matter, answers very well for this observation.

If either of the above forms of anthracene are dissolved in benzole (coal tar naphtha), a yellowish solution is obtained, which fluoresces with a brilliant green color, and gives the spectrum shown in Fig. 4, which, it will be seen by comparison with Fig. 1, differs from that of the solid substance only in the displacement of all the bands towards the violet end of the spectrum.

Fig. 4.

Fig. 5.

The same holds good with the absorption bands, as will be seen by comparing Figs. 2 and 5, which last shows the absorption spectrum of a solution of impure anthracene (*i. e.*, chrysogen) in benzole.

This is an action which has never, I believe, been observed before. I have not found it in any of the uranium salts which I have examined with this view, nor is it noted by Stokes, Becquerel or Hagenbach.

It does not, however, stand alone. Some months since, in a paper read before the American Institute in New York and the Franklin Institute in Philadelphia (see Journal of the Franklin Institute, Vol. 63, p. 296), I announced that I had found in some petroleum residues a solid substance of remarkable fluorescent power, and yielding a spectrum closely related to that of anthracene. Subsequent experiment has confirmed these results, and I hope in the next number to present a full discussion of the physical properties of this new body; but at present will only state that, as with the chrysogen above mentioned, the spectrum of fluorescence, as also that of absorption, has all its bands displaced towards the more refrangible part of the spectrum, without other change, by solution. Nor does the analogy between these bodies (*i. e.*, commercial anthracene and that described by me under the name of viridin), stop here.

By similar treatment to that already described, the colored material, which is the cause of the above-mentioned spectra of fluorescence and absorption in the viridin, may be removed, and a colorless body obtained fluorescing faintly blue, with a continuous spectrum, crystallizing in needles, and melting and vaporizing above 600° F. Insoluble in cold alcohol, slightly soluble in the same when hot, but dissolving in about 130 parts of benzole at 60° and in 90 parts at 170° F. I would propose the name Thallene for the coloring matter, which is the cause of the spectra, and Petrolescene for the white body.

No action analogous to this has been before observed, as far as I am aware.

In the case of certain uranium salts, notably the oxalate and calcic acetate, the *absorption bands* are displaced by solution. The fluorescence of these solutions is, however, so faint that I have as yet been unable to measure their bands.

I have to thank my friend Dr. G. F. Barker, of New Haven, for many courtesies in the way of references to original papers on anthracene and like bodies, and for aid in obtaining a fresh supply of material, when that on which I was first observing was exhausted.

## A SENSITIVE WATER-FALL.

By Prof. Edwin J. Houston.

The recent developments of acoustics have been rich in their revelation of the wide-spread influence exerted by sound waves, in shaping and moulding matter, when in a condition to easily allow the movement of its particles. The eye as well as the ear can now be appealed to to detect the presence of these invisible waves. At their touch light sand strewn over these membranes is heaped up in miniature hills, with even greater precision and regularity than by grosser waves by the sea-shore, the number and order of the hills, together with the relative size of their interlying valleys, not only witnessing the work of the sound waves, but also indicating their exact nature and number. Water jets, gas jets, smoke jets and flames of most all gases are also under favorable circumstances likewise affected, changing their shape, size, direction and general appearance, in the most curious manner. So delicate, indeed, are some of these methods, that waves, too feeble to allow of translation by the ear into sound, are instantly appreciated by the eye as motion.

There are many different ways in which sound waves can thus reveal their presence to the eye; we have sensitive waves both covered and naked, smoky and clear, silent and noisy; we have sensitive jets of gas, water and smoke, and many other instances of this kind of sensitiveness that will recur to the student of acoustics. I propose to add another, of quite a novel character, to the already lengthened list.

While spending a summer's vacation in Pike County, Pennsylvania, I had the good fortune to discover the sensitiveness of water to sound waves on a large scale. Among the many beautiful waterfalls in this portion of our State, I visited one in which a scanty supply of water was dripping from the moss-covered walls of a precipice. Each stream poured from the end of a pendant of moss, formed generally of one or two tiny leaflets. The air was unusually still, and the streams preserved for some distance a vein remarkably free from ventral segments. Struck with this circumstance, it occurred to me to try the sensitiveness of these streams to the notes of the voice, and after several attempts I found a tone, a shrill falsetto, to which they would respond. On sounding this note, the grouping of the drops and the position of the ventral segments were instantly changed. As the streams were of different diameters, they were not all sensitive to the

same note; but at one portion of the falls, from which about one hundred of these thin, delicate streams were dripping, a very large number of them responded. A friend who was with me, a gentleman of nice powers of observation, noticed the same phenomena.

I was unable to determine the exact conditions of success, but am satisfied that they are not easily obtained, as at several other falls, where the streams appeared nearly of the same character, none were found that would respond to the voice, although a variety of different tones were tried. At another falls, however, a number of streams were found that were almost equal to the first in sensitiveness.

A heavy rain, which flooded the streams, prevented me from extending the observation. The publication of the facts will enable others to try the experiments for themselves.

The change in the grouping of the drops and the position of the ventral segments is, no doubt, to be ascribed to a vibration communicated by the sound waves to the delicate filaments of moss from which the water flows. These act somewhat in the manner of reeds, and simulate the orifice of the ordinary sensitive jet, by whose vibration the appearance of the issuing stream is altered.

The falls at which the observation was first made are situated on Adam's Brook, near Dingman's Ferry, about 2½ miles up stream from the stage-road leading to Milford.

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## ILLUSTRATION OF RESONANCES AND ACTIONS OF A SIMILAR NATURE.

By Henry A. Rowland, C. E.,
Instructor in Physics in the Rensselaer Polytechnic Institute.

At the present day, when scientific education is beginning to take its proper place in the public estimation, anything which can help toward imparting a clear idea of any physical phenomenon becomes important. There are a number of these phenomena, of which resonance is one, which play quite an important part in nature, but which as yet have not been illustrated with sufficient clearness in the lecture-room. Among these are the following: a person carrying water may so time his steps as to produce waves which shall rise and fall in unison with the motion of his body; soldiers in crossing a bridge must not keep step, or they may transmit such a vibration to it as to break it down; window-panes are sometimes cracked by sounding a powerful organ-pipe to which they can vibrate; a tuning-fork will respond to

another of equal pitch sounded near it; and others will readily suggest themselves to the reader. In all these cases we have two bodies which can vibrate in equal times, connected together either directly or by some medium which transmits the motion from one to the other. We can, then, readily reproduce the circumstances in the lecture-room.

The vibrating bodies which I have found most convenient are pendulums: they are easily made, are seen well at a distance, and their time of vibration can be easily and quickly regulated. The apparatus can be prepared in the following manner: Fix a board, about a foot long, in a horizontal position; suspend a piece of small, stiff wire, of equal length, beneath its edge, parallel to it, and an inch or two distant, by means of threads. To one end of the board suspend a pendulum, consisting of a thread about ten or twenty inches long, to which is attached a ball weighing two or three ounces; join the thread of this pendulum to the horizontal wire by taking a turn of it around the wire, so that when the pendulum oscillates, it causes the wire to move back and forth in unison with it. To complete the apparatus, prepare a number of small pendulums by suspending bullets to threads, and let them have small hooks of wire to hang by.

Having then set the heavy pendulum in motion, hang some of the light ones on the horizontal wire, and note the result: those which are shorter or longer than the heavy one will not be affected, but if any of them are nearly of the same length, they will begin to vibrate to a small extent, but will soon come to rest, after which they will commence again, but stop as before; but if any one happens to be of exactly the proper length, its motion will soon become very great, and immensely surpass in amplitude that of the heavy one, although the motion is derived from it. Of course the heavy pendulum must be retarded in giving motion to the light one, but it is hardly perceptible when there is great difference in the weight. In the same manner a tuning-fork will undoubtedly come to rest sooner when producing resonance than when vibrating freely. To show this retardation more clearly, suspend two pendulums, equal in weight and length, to the edge of a horizontal board, and connect their two threads together by a horizontal thread tied to each at a point an inch or two from the top, and drawn so tight as to pull each of the pendulums a little out of plumb. On starting one of these pendulums the other will gradually move, and finally absorb all the motion from the first, and bring it entirely to rest; the action will then begin anew, and the motion will be entirely given back to the first ball. This experiment differs

from that of resonance, inasmuch as in the case of the pendulums all the motion of the first ball is finally stored up in the second; but in the case of resonance the confined air is constantly giving out its motion to the atmosphere in waves of sound. To imitate this to some extent we must attach a rather large piece of paper to the second pendulum, so that it will meet with resistance, and then *both* balls will come to rest sooner than otherwise. If one of the balls is only two or three times heavier than the other, they will then also interchange motions; but when the heavy ball has the motion, the arc of its vibration will not be so great as that of the other when it vibrates.

To illustrate the use of Helmholtz resonance globes, or Koenig's apparatus for the analysis of sounds, we can enlarge and modify the first apparatus somewhat. Make the board six or eight feet long, and suspend at one end four or five of the heavy pendulums, and at the other the same number of light ones, each of which corresponds in time of vibration with one of the heavy ones. On now causing any of the heavy pendulums to vibrate, as No. 3, we shall meet with no response from any of the light ones except No. 7. If Nos. 1, 2 and 4 are set going at one time, the wire A will be drawn hither and thither by the conflicting pulls with no seeming regularity, but each of the balls 5, 6 and 8 will pick out from the confused motion the vibration due to itself, and will move in unison, but No. 7 will remain quiet. The short pendulums always produce the effect sooner than the long ones. To remedy this to some extent it is well to bend the wire A into the shape shown in the figure. It is not well to make the pendulum more than twenty inches long, if a quick response is wished. There seems to be no limit to the number of pendulums which can be used or the distance to which the effect can be transmitted, though it is more decided when there are but few pendulums and they are near together. It may sometimes be more convenient to suspend the pendulums from a wire, tightly stretched, than from a board. To make the balls visi-

ble at a distance, it may be well in some cases to make them of polished steel, and illuminate them by a beam from the electric lamp.

These experiments have many advantages which recommend them to teachers: they can be performed without purchased apparatus, and can be made to illustrate resonance and the kindred phenomena in all their details. Indeed, any one will be well repaid for spending an hour in performing them, simply for their own beauty.

## WEIGHTS, MEASURES AND COINAGE—INTERNATIONAL STANDARDS—ADVANTAGES OF THE METRIC SYSTEM.

The suggestion of any change in existing habits of social or commercial life is necessarily a personal affair with every one, and on such occasions it is to be expected that many, judging from the profundity of their feelings, decide that they are competent both to advise and to judge on the matter at issue. Therefore such agitations invariably bring to the surface many hasty, ill-considered opinions, arising from want of knowledge of the real nature of the discussion, and from a deficiency in that critical judgment which is only attained by those who have the skill and patience to reduce to their fundamental principles the two systems between which they would decide.

These remarks apply especially to the recent discussions as to the relative advantages of the English and French systems of measures and weights, and it was with a feeling of satisfaction that we rose from the perusal of such an able analysis of these systems as that given by President Barnard, of Columbia College, in his "Metric System of Weights and Measures: An Address delivered before the Convocation of the University of the State of New York, at Albany, 9th August, 1871."

In the discussion of the relative merits of these systems, we can put aside the question whether the metre or the yard is the most "natural" or "religious" unit, or if one is actually or only approximately an aliquot part of any dimension of the earth; for even allowing that a unit is, in the above sense, a natural and absolute one, we can only practically know and actually use a certain bar of metal, carefully made and kept, which has legally been decided to be the unit, and it seems to us to matter little whether or not it be the one ten-millionth part of the distance from the equator to the pole of the earth; for, supposing the true unit once possessed but now lost—what have we lost? not the ideal unit, but a bar of metal legislatively de-

cided to be the unit. The only advantage of having a unit the ten millionth of the earth's mean quadrant would be a limited one to navigators; and as the semi-diameter of the earth is the only unit derived from our planet used by astronomers, we see that since the metre is a part of the earth's quadrant this unit is of no advantage to them. But, what is of consequence is (1) that when the unit has been once established that it should remain of a constant value, and should permit of being readily copied with an exactness which will render any error it may possess insignificant in any measurement to which it will be applied; (2) that it should be of a convenient length; (3) and should be divided in a manner that conforms to the system of numeration and computation of the people who daily use it. (4) Also, this unit of length should have a simple relation to the units of weight and capacity by making these latter contain the weight and measure of one cubic unit of water at a determinate temperature; and (5) finally, if possible, the weight of the unit of gold coinage should bear a simple relation to the unit of weight.

Both the yard and the metre exist as unit-bars from which copies have been made with great exactness, so that if either standard were lost it could be reproduced from the copies without appreciable error. The yard and the metre are also equally convenient to carry the metre being only 3·4 inches longer than the yard. But the advantages in all the other requirements above mentioned are in favor of the metre; for this is decimally divided, thus conforming to our system of numeration; and since notation and computation in decimal fractions are but the natural extension of our system of numeration and coinage division, both measure and computations in metric fractions are executed with greater rapidity and certainty. As an example, I take a yard-stick and measure my room, and find it 5 yards 9 inches and 5-16 inch wide, and 6 yards 1 foot 1 inch and $\frac{1}{2}$ inch long. I now take a metre-stick, and find for the width 4·808 metres, and for the length 5·813. We wish from these measures to find the area of the floor in square yards and in square metres by multiplying the width by the length measure. Let any reader perform this operation in the English measures and then in the French, and time accurately each operation. The result will convince him of the superior rapidity and certainty of the metric computation.

If the advantages of the metric system are at once apparent when applied to the determination of an area, yet more evident is its superiority over the English system when we compare them in an applica-

tion to the determination of a capacity. And the advantages of the metric system do not stop here, for as its units of weight are equal to the weights of units of capacity of water, it follows that a French engineer has instantly the weight of a stone or structure of masonry when he knows its volume and its specific gravity; whereas the English engineer has to reduce his measure of volume to cubic feet, and fractions of the same to multiply them by 62½ (roughly speaking) and the product by the specific gravity of the stone. Such operations as we have instanced are of hourly occurrence among all the men who are now advancing our civilization by the application of science, and why should such a practical people as the American waste time in such indirect processes as are required in all applications to the arts of the English system of weights and measures. In the language of the Yale Naughtical Almanac, "overcome by the influences of New England birth," Elihu Burritt calculated how much time was wasted in England by introducing the *u* into such words as favour, honour, &c. It would be really worth the muscle to drive the Albany Observatory calculating engine to a result giving the number of lives (in time) spent from using the English measures of weights instead of employing the metric system. Evidently the mental economy of the nation demands that the latter should displace the former system.

But besides the actual tyranny which we impose upon ourselves, lone considered, by adhering to the existing system, is the barrier which it presents to free commercial and industrial intercourse with the majority of civilized peoples; for, according to Dr. Barnard, over 336,000,000 have adopted the metric system against 70,000,000, in the United States and Great Britain, who still adhere to the yard and pound. Real progress either in the individual or in the nation consists in a moral and intellectual advance, and the less the variance in habits and thoughts among nations, the closer the bonds of moral and intellectual sympathy; the greater the facility of interchange of thought and of commercial relations, and the greater their mutual assistance in true progress. Now, as President Barnard remarks, "except the metric system and that which we use ourselves, no other existing, and no other likely to exist, can be advocated as having the least claim to become the system of the world. One of them, therefore, must sooner or later prevail; for no man, not totally regardless of the history of the past, and not absolutely blind to what is taking place under his own eyes in the present, can possibly pretend to believe that the world is to be forever without a uniform system of

weights and measures * * * * * one or the other must sooner or later prevail. Which shall it be? Which is it likely to be?"

Dr. Barnard now proceeds to show that "past metrological reforms are not attributable to political causes, but to the force of public opinion, and that neither the British people nor the American people are expected to accept this system unless they think it best; but the presumption of some of us is that they will sooner or later think it best." The doctor then traces the causes of indifference to change in the United States, and indicates that we must either stand alone with our measures or adopt the metric system, the universal prevalence of which in Europe is inevitable, for all causes are conspiring to its speedy adoption.

With a pleasantry worthy of Pascal, President Barnard discloses the puerility of the discussions and objections published by a member of the former Convocation Committee on the subject of a uniform system of weights and measures. Read this: "We are told that the linear unit of the system is too large. Too large for what? Too large, in the words of your committee, 'to be apprehended by a young and uninstructed mind.' This is something which I confess that *I* do not apprehend. A metre, I suppose, can be brought into the school-room, and can be seen without difficulty, even by a small boy, from end to end. I remember, when I was a very small boy myself, seeing something brought in which was about as long as a metre; and if I did not apprehend it at the time, I was at least very apprehensive of it." And this: "But there is still another practical objection, which is so perfectly well founded that I hardly know what to say about it; so that I am not sure but that the truest wisdom in me would be to let it alone altogether. It is the undeniable truth that, if we give up our present measures we shall cease to have them any longer. 'What follows?' say your committee, with anxiety, 'we have blotted from the mind of the nation the fact, and a knowledge of every measure into which it enters as a unit.' This is evidently a serious business. It reminds us of the sad case of the lad who having eaten his cake desired to have it again. The committee go on to explain that instead of twenty-five feet we will have to say something else; and instead of one hundred and forty-five miles we shall have to say something else still. And, exploring the extent of the calamity, the committee become gloomily figurative; and, speaking with deep emotion of 'the cubic foot, known wherever the English language is spoken,' they tell us that this cherished object 'is also gone, and in the twilight of its

existence we grope about for a substitute.' I do not deny that this is eloquence, but I respectfully submit that it is not argument. There cannot but be some of us who will consider that this tenderly lamented cubic foot, with its inconvenient numerical relation to the common unit of liquid capacity of 1728 to 1; and its more inconvenient relation to the common unit of liquid capacity of 1728 to 231; and its even still more inconvenient relation to the unit of dry capacity of 1728 to 2150·42, is very well out of the way." And this: "Your committee themselves are not adverse to all change. There is one modification of our system of weights which they actually propose to our acceptance. The recommendation is made, moreover, so impressively, out of a sense 'of duty plain and imperative,' that for me I was prepared for something startling; for, at the very least, a proposition to do away forever with the perfectly unnecessary troy pound. I am compelled to confess my disappointment. The proposed innovation so solemnly introduced is explained in the following words: 'In analyzing these weights, it is found that the ounce in the apothecaries' weight and the same in the weight troy are identical, and that each exceeds the ounce avoirdupois by its eighty-three thousandth part very nearly; hence, if the ounce troy or the apothecaries' ounce be diminished by its eighty-three thousandth part, the result will be the ounce avoirdupois, or the one-thousandth part of the weight of a cubic foot of distilled water, and then these three weights will have a common unit.' I have pondered this passage profoundly, but I have not been able to see my way to the bottom of it. It has been my lot to be compelled to transform troy ounces into avoirdupois ounces very frequently; but I have always found the difference to be 42·5 grains."

After these quotations the reader may re-peruse with advantage the introductory paragraph of this article.

Not the least valuable part of this work of Dr. Barnard is the "Note on the Unification of Moneys," forming Appendix A: "To touch an interest of such vast magnitude as the coinage of the world is a thing which to be done safely must be done cautiously," for the world's existing coinage amounts to three thousand millions of dollars. Our space will not permit us to do justice to Dr. Barnard's comprehensive discussion of this important international problem, for we are convinced from a careful study of it that it is the clearest and most reliable exposition of this subject ever published in America. It must suffice to give the following abstracts: "It is an opinion easily taken up upon a *prima facie* view of the subject, that the pound sterling o

Great Britain, the dollar of the United States, and the franc of the French Republic, might, by the simplest process of legislation in the world, be reduced to a regular geometrical series of values. Hence, therefore, it is probable that everybody, who knows anything about these important national money-units and the relations in which they stand to each other, has often said to himself, in the language of one of the resolutions reported to the Convocation of the University of the State of New York, by this Committee on Weights, Measures and Coinage, that 'such changes should be made in the values of the franc, the dollar, and the English pound sterling, that twenty-five francs be exactly equal in value to one pound sterling.' It was surely not an observation so little profound as this, that the Convention had a right to expect of their committee. Considered as a help toward the attainment of the desired uniformity of currencies, it rather reminds one of good Mrs. Nickleby's very practical suggestion to her embarrassed husband, 'My dear Nicholas,' said the excellent lady, 'why don't you do something? Why don't you make some arrangement?' * * * The sundry international conferences which have been called during the last fifteen years to consider this subject, have not wasted breath in axiomatic propositions and empty generalities, but have given all their collected strength to the study of the knotty problem, *how* this thing is to be done. The solution of this problem is considered by the ablest publicists and profoundest financiers of all nations to be one of the most perplexing with which legislation has to grapple."

Dr. Barnard in this appendix clearly states the difficulties in the road to a speedy adoption of one international coinage. There are many, the fundamental being that in France and the United States both silver and gold are standard metals, while in England only gold is the standard, while the real silver standard coin (the franc of nine parts of pure silver to one of alloy, of a weight of five grammes) has actually ceased to exist, the present silver coinage of France being a debased coinage; and this is nearly the case in the United States for silver coins below the silver dollar. Therefore, before the solution of the problem can begin, the nations have to decide whether gold or silver shall be the standard. Another difficulty in the way is the diversity and variability in the standard of fineness.

President Barnard closes his discussion with these suggestive considerations: "If Germany has failed to grasp the favorable occasion for reconciling the conflicting monetary systems of Europe, she has nevertheless brought order out of the confusion of her own. Hence-

forth, in reference to this matter, she contributes but a single element instead of many to the general discord; and permits us to say that the number of the inharmonious elements which, in studying the question of unification, we are compelled to consider is practically reduced to these four: the mark, the franc, the pound sterling and the dollar. The relations which these bear to each other, as presented in the weights and values of their characteristic gold coins most nearly approximate, are given here—the weights being expressed in grammes and milligrammes, and the values in the currency of the United States:

| | | Weight pure gold. | Weight standard gold. | Value. |
|---|---|---|---|---|
| Germany, | 20 mark piece, | 7·168 | 7·965 | $4 764 |
| France. | 25 franc piece (proposed), | 7·258 | 8·035 | 4·824 |
| Great Britain, | Sovereign, | 7·322 | 8·136 | 4·865 |
| United States, | Half eagle, | 7·523 | 8·359 | 5·000 |

In this exhibit we have the whole case immediately under the eye. Till Germany intervened the widest range of difference between the representative coins of the systems which it seemed most important to reconcile, was less than eighteen cents. She has extended it to nearly twenty-four.

The very hopelessness of the case in the aspect here presented imposes upon the four great powers above named the obligation to lend their most serious attention to every alternative possibility of relief which may be suggested; and, in the actual state of things, it is eminently well worth their consideration, whether present effort should not be directed toward the creation of a coinage for international use on a plan entirely independent of all local and purely national systems. Such an international coinage, though not in strictly commensurate relations with the coins now actually in use, would be productive of the great benefit of immensely simplifying commercial exchanges, and of providing travellers with a currency everywhere invariable in value. The advantages which its introduction would bring with it, are to some extent even now actually enjoyed throughout a large part of Europe, in consequence of the extended circulation which the gold Napoleon secured beyond the limits of the French territory. But though it circulates freely all over Germany, Austria, Holland, Denmark and Sweden, it circulates only by toleration, and because of its great convenience, and is not a legal-tender for payments of any amount in any of those countries.

"The international coinage here suggested will command, if estab-

lished, an immediate circulation among all the peoples who shall unite in its creation, and will bring with it greater advantages than have attended the continental circulation of the napoleon. The existence of such a coinage will, moreover, keep constantly before the minds of all those who use it the desirability of a currency which shall not be only international, but everywhere uniform and identical. Thus the proposed coinage may become a powerful instrumentality in promoting the attainment of the object for which it seems at first to be only designed as a substitute, the ultimate complete unification of the monetary systems of the world.

"An international coinage devised without reference to systems actually existing, and controlled in its principles by no considerations of what may be their discordances or resemblances, may be, moreover, constructed on a strictly scientific plan, and thus, when time shall have familiarized the nations with its values and its visible forms, it may happen that without violence, and by the spontaneous action of people themselves, diversity may silently give place to uniformity, and a better system than any which present legislation could create, may ultimately prevail throughout the world." DR. A. M. MAYER. —*N. Y. Evening Post, March* 7, 1872.

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**Dying Veneer Wood.**—C. Mène recommends that the wood be steeped for twenty-four hours in a solution of caustic soda and boiled with it for one-half hour. After washing to remove all the lye, it will be found to have become as soft as leather, and equally elastic, and to be in excellent condition to absorb the dye-stuffs. The dyes are fast and thoroughly penetrate the wood, which after drying may be sawed and veneered.

**New Observations Concerning Ozone.**—Recent observations by Gorup-Besanez have proven that ozone is formed during the evaporation of water. The experiments were conducted near the gradation works at Kissingen. The author draws therefrom the conclusion that the air upon and near the ocean should be richer in ozone than that of inland localities. The results of experiments made by other investigators seem to confirm the view.

**Separation of Copper and Silver.***—Mr. R. Palm proposes to evaporate the nitric acid solution of the two metals to the consistency of syrup, and to treat this with concentrated nitric acid free from hydrochloric acid. The silver nitrate is insoluble in strong nitric acid, and is precipitated as a crystalline powder, which is to be filtered and washed with strong acid to remove any traces of copper.

Polytech. Notiz-Blatt., 1872, No. 5.

# Bibliographical Notices.

*On the Periodicity of the Aurora Borealis.* By Joseph Lovering. [From the Memoirs of the American Academy, New Series, Vol. X].

Prof. Lovering has manifested his interest in meteorological subjects, in various ways, since the great "star-shower" of 1833. He was, we believe, the first public advocate of the now generally accepted theory, that the apparent radiation of the November meteors from the constellation Leo, is an effect of perspective. His corps of observers, among the undergraduates of Harvard, were co-workers with Olmsted's corps, among the undergraduates of Yale, and the Cambridge observations, under his direction, not only established the perspective theory, but also cultivated a fondness for meteorological investigation, which has led to many important practical results.

On the 11th of October, 1859, Prof. Lovering communicated to the American Academy a paper on the Secular Periodicity of the Aurora Borealis, accompanied by a catalogue of 624 auroras, compiled from the journals of Winthrop, Wigglesworth, Holyoke and Hale. At the close of the communication he announced his proposal "to publish immediately, in a second memoir, a complete catalogue of auroras, and then to renew the discussion in regard to the periodicity of the phenomenon with more ample materials." The work under notice, which has been issued in pursuance of this plan, furnishes a monument of patient observation and research, which will not only redound to the permanent reputation of its author, but will also prove a valuable Thesaurus of information to all investigators of auroral or other correlated phenomena. The systematic arrangement, in various groups, of 12,382 observations, the graphic delineation of resulting curves for various periods and localities, and the cautious weighing of evidence for and against many of the popular theories, will commend the work to true scientists, and will doubtless stimulate others to further valuable research.

P. E. C.

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*Reports on Observations of Encke's Comet during its Return in* 1871. By Asaph Hall and William Harkness, Professors of Mathematics, U. S. Navy. [Washington Observations for 1870, Appendix II].

This joint paper is a valuable contribution to our knowledge of a comet which is viewed by astronomers with especial interest on account of its supposed indications of a resisting interstellar medium.

The report of Prof. Hall gives in detail 284 stellar comparisons in right ascension and 91 in declina- tion, comparing the resulting positions with the ephemeris of S. von Glasenapp, and illustrating the various cometary phases by notes and engravings. Prof. Harkness describes the telescope and spectroscope employed, with the method of observation, records the observations, with accompanying notes, discusses at some length the density of Encke's supposed resisting medium in space, and closes with the following summary of results:

1. Encke's comet gives a carbon spectrum.
2. From Nov. 18 to Dec. 2 the wave-length of the brightest part of the second band of the comet's spectrum was continually increasing.
3. No polarization was detected in the light of the comet.
4. The mass of Encke's comet is certainly not less than that of an asteroid.
5. The density of the supposed resisting medium in space, as computed from the observed retardation of Encke's comet, is such that it would support a column of mercury somewhere between $\frac{220}{10^{17}}$ and $\frac{285}{10^{20}}$ of an inch high.
6. There is some probability that the electric currents which give rise to auroras are propagated in a medium which pervades all space, and that the spectrum of the aurora is, in reality, the spectrum of that medium.
7. It is not improbable that the tails of all *large* comets will be found to give spectra similar to that of the aurora, although additional lines may be present.

P. E. C.

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# Franklin Institute.

*Proceedings of the Stated Meeting, April* 17, 1872.

The meeting was called to order, at the usual hour, by the President, Mr. Coleman Sellers.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were submitted by the Actuary, and the list of donations to the library which had been made since the last meeting, which consisted of the following:

From the Oesterreichischen Geologischen Reichsanstalt, Vienna, Austria; from the Societé pour l'encouragement de l'Industrie Nationale, Paris, France; from the American Institute, N. Y., 7 volumes of